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THE PRAIRIE NATURALIST, Volume 37, No. 1, March 2005

THE PRAIRIE NATURALIST

Volume 37 No. 1

THE PRAIRIE NATURALIST

Volume 37, No. 1 **March 2005**

The Prairie Naturalist **is printed at Fort Hays State University Printing Services.**

Lesser Prairie-chicken Use of Harvested Corn Fields during Fall and Winter in Southwestern Kansas

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ABSTRACT -- The lesser prairie-chicken (*Tympanuchus pallidicinctus*) has declined in numbers in Kansas primarily due to the conversion of sand sagebrush (*Artemisia filifolia*) prairie to cropland. The lesser prairie-chicken in Finney County, Kansas exists primarily in large fragments of sand sagebrush prairie, and it forages during fall and winter on waste grain in harvested corn *(Zea mays)* fields adjacent to prairie fragments. We used radio-telemetry to monitor lesser prairie-chicken locations and found no significant relationship between numbers of bird locations and amounts of waste grain on the ground in harvested corn fields. Even the harvested fields with the least amount of waste grain seemed to have sufficient amounts of food available for foraging lesser prairie-chicken. There appeared to be no need to develop supplemental food sources for wintering lesser prairie-chicken populations that have access to harvested fields of irrigated corn in Finney County.

Key words: corn fields, foraging, Kansas, lesser prairie-chicken, *Tympanuchus pallidicinctus*.

The lesser prairie-chicken *(Tympanuchus pallidicintus)* is a prairie grouse restricted to the south-central plains of North America. It inhabits rangelands dominated by shinnery oak (*Quercus harvardii*), sand sagebrush (*Artemisia filifolia*), and mid-grass prairie. Habitat deterioration combined with intensive

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grazing, human disturbances, and conversion of rangelands to cropland have reduced lesser prairie-chicken populations greatly since the early 1900's (Giesen 1998). The lesser prairie-chicken was petitioned in 1995 for listing as threatened under the Endangered Species Act. The U.S. Fish and Wildlife Service determined that listing was "warranted but precluded" (U.S. Department of the Interior, Fish and Wildlife Service 1998) and the status of the lesser prairie-chicken population is being monitored closely across its current range (Mote et al. 1999).

Conversion of sand sagebrush rangeland to center-pivot irrigated cropland has destroyed and fragmented much of that habitat in southwestern Kansas. Initially the development of irrigated cropland, primarily corn *(Zea mays)* and grain sorghum *(Sorghum vulgare)*, resulted in increased numbers, or greater concentrations, of lesser prairie-chicken (Rodgers 1995). However, as the conversion of sand sagebrush habitat to cropland became more widespread, lesser prairie-chicken numbers declined drastically in Kansas (Jensen et al. 2000). The lesser prairie-chicken in Finney County of southwestern Kansas commonly forages in harvested fields of irrigated corn during fall and winter (Jamison 2000). These harvested fields now might be instrumental in maintaining isolated lesser prairie-chicken populations where suitable fragments of sand sagebrush remain. We initiated our research to determine if lesser prairie-chicken preferentially foraged in harvested corn fields with higher amounts of waste grain on the ground versus fields with less waste grain available.

STUDY AREA

We conducted our study in Finney County of southwestern Kansas (37° 52' N, 100° 59' W), primarily on a 5,760-ha fragment of sand sagebrush prairie surrounded by agricultural fields irrigated by center-pivot systems. Average annual precipitation was 48 cm with 75% of it falling between March and August; mean annual temperature was 12.7° C, ranging from means of -6.1° C in January to 26.0° C in July.

The sand sagebrush prairie was dominated by sand sagebrush interspersed with grasses such as blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon hallii*), and little bluestem (*Schizachyrium scoparium*). Other plants common on the area included western ragweed (*Ambrosia psilostachya*), annual eriogonum (*Eriogonum annum*), plains yucca (*Yucca glauca*), plains prickly pear (*Opuntia polyacantha*), and Russian thistle (*Salsola iberica*) (Hulett et al. 1988). Over 90% of the study area was grazed seasonally by cattle *(Bos taurus)*.

Surrounding cropland was devoted predominantly to the production of corn, wheat *(Triticum aestivum)*, and alfalfa *(Medicago savita)*. We confined our efforts to irrigated corn fields and the adjacent sand sagebrush areas. Corn fields

were harvested with six- to eight-row self-propelled corn combines in late September and early October. Corn stalks were left standing after harvest and the fields remained untilled until spring planting time.

METHODS

We estimated the amount of waste grain on the ground in six harvested corn fields at monthly intervals during October through January 1998-1999 and November through February 1999-2000. We subjectively selected the corn fields for our study from fields that historically had been used for foraging by lesser prairie-chicken resident in adjacent sand sagebrush prairie (Jamison 2000). Two pairs (fields adjacent to each other) plus two isolated fields were included in the study during 1998-1999 and three pairs in 1999-2000, but those were not necessarily the same fields each year. The fields were square quarter sections of land (64.8 ha) with elevated sprinkler booms extending from central water sources to the outer edges of the fields. The circular rotation of the booms provided surface water to the entire field when in operation, primarily during spring and summer.

In each corn field, four 350-m transects, radiating outwardly from the center of the field, were established. The azimuth bearing (0° = north) of the first transect was determined randomly whereas the other three were established 90°, 180°, and 270° from the first. Each month we collected the surface material and top 1.3 cm of soil from eight randomly located 20- x 20-cm plots along each transect. We collected the top 1.3 cm of soil because corn kernels in that soil stratum might be available to foraging lesser prairie-chicken. We pooled the material from the eight plots as the sample for the transect. Monthly samples from the four transects in each field constituted the basis for estimating the amount of grain available to foraging lesser prairie-chicken. We recovered waste corn from our samples by using a sieve to separate corn kernels from soil and debris. Corn kernels were oven-dried at 40° C for 7 days prior to determining their mass; waste grain abundance is reported as g/m^2. Differences in waste corn abundance in harvested fields were detected by subjecting the monthly waste corn mass (g/m^2) data to a randomized block analysis of variance with $P < 0.05$ for significance.

We determined corn fields in which the lesser prairie-chicken was foraging by monitoring transmitter-equipped birds. Lesser prairie-chickens were trapped on breeding areas (leks) in the sand sagebrush rangeland during spring and fall and equipped with 11-g necklace-style transmitters with a life expectancy of 6 to 12 months. These birds where thereafter located daily (locations determined equally during three daytime periods: morning, mid-day, and afternoon/evening) by triangulation at a distance of 1 to 2 km (Jamison 2000). Generally, after corn fields adjacent to the sand sagebrush rangeland were harvested, lesser prairie-chicken in those rangelands made daily foraging flights to those fields in the early morning

and late afternoon. We had 23 and 19 individual lesser prairie-chicken equipped with transmitters on our study area in the fall of 1998 and 1999, respectively. The number of daily locations of the birds in the corn fields was our measure of use with the higher numbers of locations reflecting higher use. We determined if the use of corn fields by lesser prairie-chicken each month was related to available waste grain by correlating the number of recorded telemetry locations in corn fields with biomass of waste grain in those fields. The 1998-1999 field layout included two pairs (adjacent) of fields and two individual fields whereas the 1999-2000 field layout included three pairs. For 1998-1999 there were four experimental units: the two individual fields and two pairs (each field pair was considered as an experimental unit). Similarly, for 1999-2000 there were three experimental units, which were the three field pairs. Field and year means were compared by using analysis of variance with a significance level of 0.05 and Fisher's protected LSD was used for field mean comparisons, as appropriate. We used Spearman rank correlation coefficients to quantify the linear relationship between the amount of waste grain and the number of bird locations in the individual fields. The year-month-field means were computed for each field for both the amount of waste grain and the number of bird locations. The year-month-field means for these two variables were used in the correlation analysis and year-month means were based on the average of six fields. Correlations were computed by month within years and by month over both years.

RESULTS

During the two-year study, 1,536 ground samples were collected from 12 harvested corn fields. Biomass ranged from 13.4 to 321.2 g/m^2 within fields throughout the 1998-1999 sampling period (Table 1) and from 11.1 to 137.6 g/m^2 within fields throughout the 1999-2000 field season (Table 2). The amount of waste corn biomass varied among fields ($F = 3.33$, $df = 5, 15$, $P = 0.03$) and decreased ($F = 8.77$, $df = 1, 15$, $P = 0.01$) over time during both winters.

We recorded 1,633 and 1,411 locations of transmitter-equipped lesser prairie-chicken during the 1998-1999 and 1999-2000 field seasons, respectively. Of the total locations, 321 and 295 were in corn fields in which waste grain abundance was measured during 1998-1999 and 1999-2000, respectively.

During 1998-1999 the highest number of lesser prairie-chicken locations (165) in corn fields occurred in October whereas the lowest number (47) was recorded in January (Table 1). The numbers of lesser prairie-chicken locations in 1998-1999 were not related significantly to the amount of waste grain in those fields during October ($n = 6$, $r^2 = 0.57$, $P = 0.08$), November ($n = 6$, $r^2 = 0.36$, $P = 0.21$), December ($n = 6$, $r^2 = 0.16$, $P = 0.42$), or January ($n = 6$, $r^2 = 0.07$, $P = 0.62$). The number of lesser prairie-chicken locations in the six fields was not related significantly to the

Table 1. Amount of waste grain (g/m^2) on the ground in harvested corn fields and number of locations of lesser prairie-chicken in those fields, 1998-1999, Finney Country, Kansas.

	October		November		December		January	
Field[1]	Corn	Locations	Corn	Locations	Corn	Locations	Corn	Locations
A_1	91.5	2	93.7	4	14.0	2	20.9	2
A_2	57.2	38	48.5	13	50.2	2	36.8	2
B_1	251.8	3	67.7	2	13.4	11	17.6	13
B_2	321.2	11	219.6	25	131.0	8	23.2	14
C	72.0	30	53.6	55	28.6	15	13.8	10
D	114.1	12	81.7	33	143.7	16	101.1	4
$\bar{x}$ (total)	151.3a[2]	(96)	94.1a	(132)	66.6a	(54)	35.6b	(39)

[1] Fields identified by the same letter were adjacent to each other.
[2] Means sharing the same letter do not differ ($P > 0.05$).

Table 2. Amount of waste grain (g/m^2) on the ground in harvested corn fields and number of locations of lesser prairie-chicken in those fields, 1999-2000, Finney County, Kansas.

	November		December		January		February	
Field[1]	Corn	Locations	Corn	Locations	Corn	Locations	Corn	Locations
A_1	34.7	1	26.6	0	49.9	1	21.9	0
A_2	42.7	22	32.4	2	11.1	10	12.5	17
B_1	42.2	7	33.3	22	16.1	3	14.7	1
B_2	27.6	0	27.9	12	11.1	14	11.8	7
C_1	24.0	7	15.0	20	14.7	7	14.6	13
C_2	126.2	40	137.6	27	40.1	43	21.2	33
$\bar{x}$ (total)	49.6a[2]	(77)	45.5a	(83)	23.8a	(78)	16.1b	(57)

[1] Fields identified by the same letters were adjacent to each other.
[2] Means sharing the same letter do not differ ($P > 0.05$).

amount of waste grain in the fields when October to January data were pooled for 1998-1999 ($n = 24$, $r^2 = 0.03$, $P = 0.42$).

During fall and winter 1999-2000, we recorded 83 locations of lesser prairie-chicken in corn fields in December, whereas in February we located those birds in corn fields only 57 times (Table 2). The number of locations of lesser prairie-

chickens in harvested corn fields was not related significantly to the biomass of waste grain during November ($n = 6$, $r^2 = 0.36$, $P < 0.21$), December ($n = 6$, $r^2 = 0.01$, $P = 0.87$), January ($n = 6$, $r^2 = 0.02$, $P = 0.78$), or February ($n = 6$, $r^2 = 0.01$, $P = 0.74$). When all months and locations were pooled for the 1999-2000 field season, the number of locations of transmitter-equipped birds was not correlated significantly with the amount of waste grain on the corn fields ($n = 24$, $r^2 = 0.02$, $P = 0.54$).

DISCUSSION

We expected to find some differences in the amount of waste grain on the ground in the harvested corn fields but we were surprised at the magnitude of the differences encountered. A five to six fold difference existed in the biomass of waste grain on the ground of our six fields at the start of our 1998-1999 and 1999-2000 field seasons. These differences probably reflected different efficiencies of the combines used to harvest the corn. Well maintained corn combines generally were 95 to 98% efficient at removing corn kernels from cobs on corn stalks, but could be much less efficient if the corn head and snapping bars were adjusted improperly (Johnson and Lamb 1966). Maturity and moisture content of the corn, ground speed of the combine, header height and auger positioning, weedy fields and lodged stalks, and other variables affected the efficiency of the combine in separating kernels from corn cobs (Griffin 1973). We had no control over these variables in our study and could not estimate the contribution of each to the amount of waste grain in the harvested corn fields studied.

The amount of waste corn on the ground of harvested fields decreased over time, as observed previously by Baldassarre et al. (1983) and Warner et al. (1989). Foraging by lesser prairie-chicken was not the sole cause of the temporal decrease in waste grain because other animals foraged on waste grain in the harvested corn fields. Ring-necked pheasant (*Phasianus colchicus*), American crow (*Corvus brachyrhynchos*), and other seed-eating birds commonly were observed feeding in the fields during our study. Tracks, trails, and additional sign of Ord's kangaroo rat (*Dipodomys ordii*) and other rodents were abundant in the harvested corn fields. The combined foraging activity of this mix of avian and mammalian species doubtlessly caused the amount of waste grain in the fields to decline from October to February. Even so, the amount of waste grain remaining on the ground towards the end of winter was substantial.

In January 1999 and February 2000, our harvested corn fields had an average of 35.6 and 16.1 g/m^2 of waste grain left in them, respectively. A 100-g sample of corn from our fields contained 280 kernels. Thus, at the end of our 1998-1999 field season, approximately 100 corn kernels were present on each m^2 of ground surface and approximately 45 per m^2 were available in February 2000 (equates to approximately 12 and 5 bushels of waste corn/hectare, respectively). Even fields

with the least amount of waste grain at the end of our field seasons (field C in January 1999 and B_2 in February 2000) had 39 and 33 corn kernels/m^2 (approximately 5 and 4 bushels/ha), respectively.

Generally, lesser prairie-chicken use of fields with more waste grain on the ground was not greater than fields with less. These results were unexpected as we hypothesized that harvested fields with more waste grain would be more attractive to foraging lesser prairie-chicken, which is what long-standing optimal foraging theory would predict (Emlen 1966, Schoener 1971). However, we think the amount of waste grain in our harvested corn fields was above the threshold that would elicit preferential use of fields with higher amounts of waste grain (i.e., the least amount of waste grain in any of our fields appeared sufficient to meet the foraging demands of lesser prairie-chicken). Food scarcity commonly is associated with increased expenditures of time spent foraging by birds resulting in increased mortality (Lima 1986, Brittingham and Temple 1988, Newton 1998). We did not measure time-budgets of lesser prairie-chicken on our study area during late fall through early winter but did monitor survival. Mortality of lesser prairie-chicken was low during the October to February period (Hagen 2003), which suggested that foraging activity did not increase sufficiently to cause an increase in mortality as a result of depleted food supplies.

MANAGEMENT IMPLICATIONS

Management plans for improving habitat for declining prairie chicken populations often include developing winter food supplies (Horak 1985, Giesen 1998). However, apparently waste grain in harvested corn fields surrounding fragments of sand sagebrush prairie habitat provided an adequate source of winter food for lesser prairie-chicken in Finney County. Because nest success and brood survival of lesser prairie-chicken are associated closely with amounts of remaining sand sagebrush prairie habitat in Finney County (Pitman 2003, Hagen 2003), attempts to convert any of that sand sagebrush prairie to food plots would be counter productive.

ACKNOWLEDGMENTS

We thank the J. O. Cattle Company, Sunflower Electric Power Corporation, Thornton Cattle Company, and R. Greathouse for property access. Financial and logistical support was provided by the Kansas Agricultural Experiment Station (Contribution No. 04-023-J), the Division of Biology at Kansas State University, Westar Energy Corporation, and the Kansas Department of Wildlife and Parks (Federal Aid in Wildlife Restoration project W-47-R).

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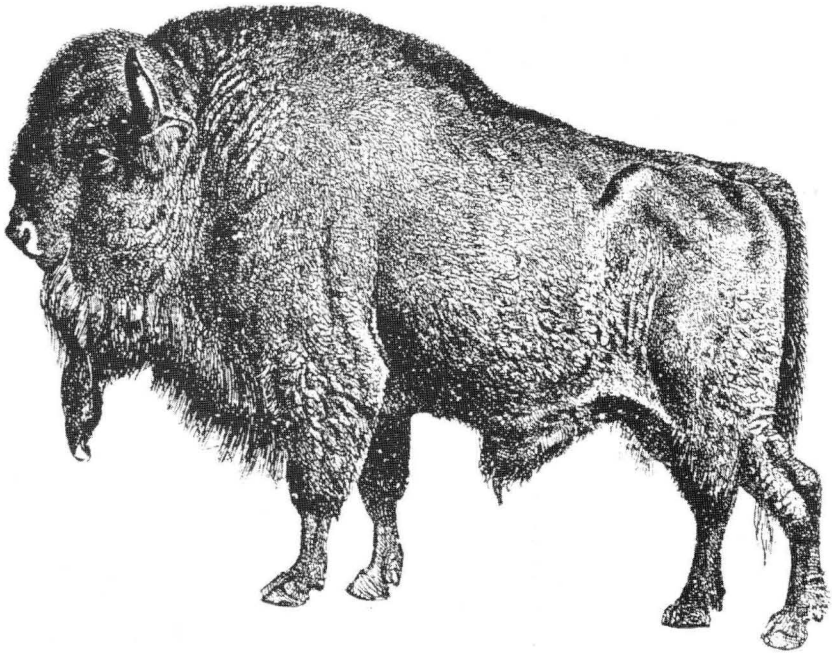
Received: 2 November 2003 *Accepted: 24 May 2005*



Daphnia lumholtzi, an Exotic Zooplankton, Invading a Nebraska Reservoir

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ABSTRACT -- A limnological assessment project by the University of Nebraska at Kearney and the Nebraska Game and Parks Commission collected weekly vertical zooplankton tows during May through September 2002 at Harlan County Reservoir in Nebraska. Beginning on 5 August 2002, the exotic *Daphnia lumholtzi* (Cladocera: Daphniidae) appeared at a density of 0.04 l^{-1} in one of fifteen standardized sampling stations. By 6 September 2002, *D. lumholtzi* was found in all fifteen stations at an average density of 2.17 ± 3.10 l^{-1} with a site maximum density of 11.43 l^{-1}. Length measurements of *D. lumholtzi* ranged from 0.80 mm to 5.66 mm with a mean length of 2.38 ± 1.107 mm. During sampling, the abundance of *D. lumholtzi* increased relative to the native *Daphnia retrocurva* from less than 1% to greater than 45% of all zooplankton collected. Our finding represents the first account in a Nebraska water system of *D. lumholtzi*, a native of Africa, Asia, and Australia, and shows a northern expansion in the Great Plains of this exotic species.

Key words: Cladocera, *Daphnia lumholtzi*, first account, Harlan County Reservoir, Nebraska, non-indigenous, zooplankton.

North American ecosystems have been invaded by many species of plants and animals, which become established either intentionally or by accident. Once established, these species often spread and in some cases cause significant harm to the environment, existing food webs, native species, and exotic commercial

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species (Pimentel 2002). Several traits, including high reproductive rates, high dispersal rates, and broad environmental tolerances (Mooney and Drake 1986), are common to successful invasive species. However, predicting rates of spread and invader success in new habitats remains problematic (Williamson and Fitter 1996). Invasive species face significant abiotic and biotic challenges in new environments and the most successful invaders often possess adaptations to disturbed habitats and protection from generalist predators (Mooney and Drake 1986).

Water fleas (Cladocera) possess life history characteristics that might make them successful invaders of new habitats. These characteristics include rapid life cycles, the ability to reproduce parthanogenetically, the production of resistant resting stages, and the production of defensive morphology, including the formation of spines, in the presence of vertebrate and invertebrate predators (Work and Gophen 1999). The recent invader *Daphnia lumholtzi* possesses defensive spines that are larger than any native daphnid species. Because of this morphology, *D. lumholtzi* might pose a significant risk to North American aquatic ecosystems by disrupting food chains and reducing feeding efficiency of planktiverous fish (Swaffer and O'Brien 1996, Kolar et al. 1997).

Daphnia lumholtzi is a native to Australia, southern Asia, and eastern Africa (Gophen 1979, Benzie 1988). It was first discovered in North America in 1991 in a small Texas reservoir (Sorensen and Sterner 1992). Since its initial discovery, *D. lumholtzi* has been found in reservoirs, rivers, and lakes in Alabama, Arkansas, Florida, Illinois, Kansas, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, and recently in the Great Lakes (Sorensen and Sterner 1992, Havel and Herbert 1993, Stoeckel et al. 1996, Dzialowski et al. 2000, Muzinic 2000, USGS 2003). In field and laboratory experiments, Lennon et al. (2001) showed that *D. lumholtzi* becomes abundant in late season when water temperatures are above 25° C and that this increase often corresponds with a decline in native species. The authors suggested that water temperature is a factor in *D. lumholtzi* distribution, limiting it to areas where water temperatures remain above 10° C.

As part of a limnological monitoring project in Harlan County Reservoir in south-central Nebraska, we collected zooplankton and water quality data during 2002. Analysis of collections revealed *D. lumholtzi*, representing the first record of this species in Nebraska.

METHODS

Zooplankton samples were collected weekly from Harlan County Reservoir starting 9 May 2002 and ending 6 September 2002. The reservoir is located in south-central Nebraska between Republican City and Alma (Fig. 1) and covers more than 52 km^2 (13,000 surface acres) at conservation pool. The primary purpose

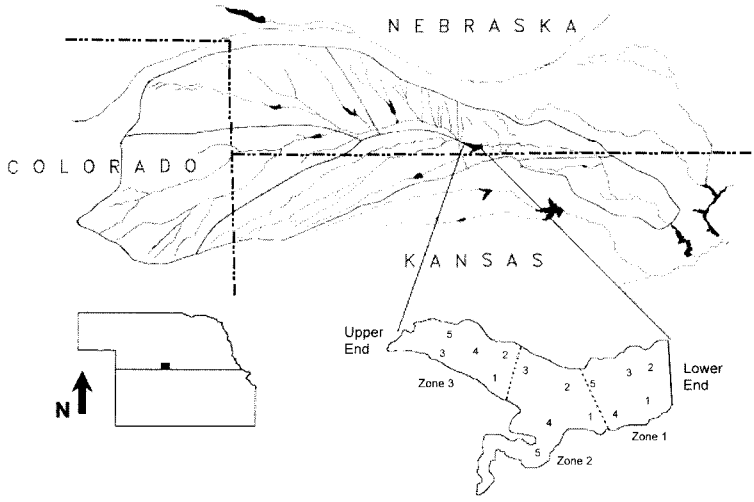

Figure 1. Map of Harlan County Reservoir showing locations of the three zones and five sample stations per zone used to collect zooplankton and limnological data.

of this reservoir is flood control, but it also is used heavily for recreation including fishing and boating. In addition, Harlan County Reservoir is operated for irrigation. Irrigation withdrawals from the reservoir often exceed 3.5 m vertically each year and reservoir filling is dependent on Republican River inflows. Consequently, reservoir elevations are highly variable.

For our study, the reservoir was divided into three zones with five stations in each zone (Fig. 1). At each station an 80-µm Wisconsin plankton net (0.5 m^2 opening) was towed vertically from the substrate to the surface. Samples were preserved in a 4% formalin and sucrose solution to prevent osmotic distortion (Haney and Hall 1973).

Zooplankton, including *D. lumholtzi*, were counted and identified to lowest possible taxon under 20-25X magnification with a Leica Stereomicroscope. Each station sample was diluted to 200 ml, from which four 1 ml subsamples were drawn with a Hensen-Stempel pipette. These samples were placed within the channel of a Ward counting wheel. Each 1 ml subsample was counted and identified individually and a mean was calculated for zooplankton per liter towed.

All observed *D. lumholtzi* from each station sample were measured with an American Optical compound light microscope under 40X power. The number

measured increased from 3 across all samples to more than 340 individuals (Table 2). Measurements were then converted to millimeters by using a Wards stage micrometer. *Daphnia lumholtzi* were measured by standard length (SL), body length (BL), and total length (TL) (Fig. 2). Water temperature and dissolved oxygen concentration were taken at 1 m depth intervals at all sampling stations on each date by using a YSI Model 55 dissolved oxygen meter. Means and standard deviations are given for body measurements and means and standard errors are given for water variables.

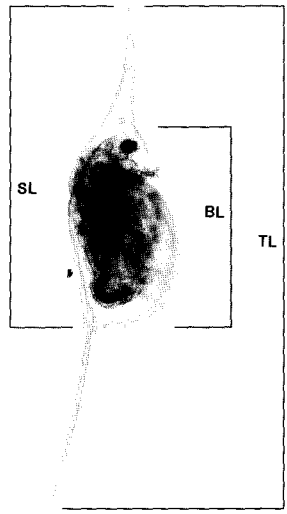

Figure 2. Measurements (mm) taken on *Daphnia lumholtzi*. SL = standard length, BL = body length, and TL = total length.

RESULTS

Daphnia lumholtzi was discovered in one station on 5 August 2002 at a density of 0.04 l^{-1}. The number of stations with *D. lumholtzi* increased until September 2002, when *D. lumholtzi* was found at all fifteen sampling stations at a mean density of 2.17 ± 3.10 l^{-1} and an individual station maximum density of 11.43 l^{-1} (Table 1). Native *Daphnia* (*D. pulicaria* and *D. retrocurva*) also were present in samples that included *D. lumholtzi*. *Daphnia pulicaria* constituted a low proportion of the total cladocerans and was found at only two stations from 5 August 2002 to 6 September 2002 (Fig. 3). *Daphnia retrocurva* was the most

Table 1. Number of sampling stations out of 15 and mean (± 1 S. D.) density of *Daphnia lumholtzi* per liter during 2002 for Harlan County Reservoir, Nebraska. Mean (± 1 S. E.) water temperature (°C) and dissolved oxygen concentration (ppm) of all sampling stations in Harlan County Reservoir for dates containing *D. lumholtzi*.

Date	# of Stations	Density (l^{-1})	Water temperature (°C)	Dissolved Oxygen (ppm)
August 5	1	0.04	25.1 ± 0.46	6.74 ± 0.29
August 19	6	0.04 ± 0.009	24.8 ± 0.55	
August 23	4	0.05 ± 0.019	24.5 ± 0.29	8.75 ± 0.27
August 28	10	0.20 ± 0.158	23.9 ± 0.49	6.57 ± 0.34
September 6	15	2.17 ± 3.104	22.9 ± 0.09	7.21 ± 0.11

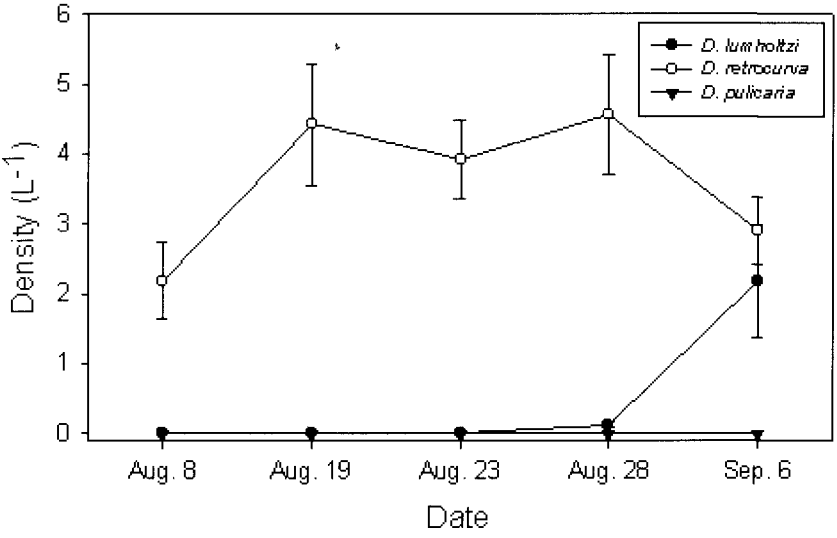

Figure 3. Mean (± 1 S. E.) density of zooplankton per liter from Harlan County Reservoir for five sampling dates in 2002 (15 samples per date). *Daphnia lumholtzi* is exotic while *D. pulicaria* and *D. retrocurva* are native species.

abundant cladoceran and was found at all fifteen stations during the time that *D. lumholtzi* was present. The proportion of *D. retrocurva* declined sharply between 28 August and 6 September at the same time that *D. lumholtzi* increased from about

3% to about 43% of the total cladocerans (Fig. 3). Mean water temperature declined between 8 August and 6 September. Mean dissolved oxygen fluctuated but remained between 75 and 95% of air saturation (Table 1).

The total length of *D. lumholtzi* ranged from 0.80 mm to 5.66 mm with a mean total length of 2.38 ± 1.11 mm per individual during the period when *D. lumholtzi* was most abundant on 6 September 2002 (Table 2). Body lengths were similar among sample periods except for 19 August when individuals tended to be smaller than in other samples (Table 2). The spine lengths accounted for between 57 and 65% of the total length of *D. lumholtzi*.

Table 2. Mean standard length, body length and total length (± 1 S. D.) of the exotic *Daphnia lumholtzi* and the native *Daphnia pulicaria* collected from Harlan County Reservoir, Nebraska during 2002.

	Daphnia lumholtzi				*Daphnia pulicaria*	
Date	Standard Length (mm)	Body Length (mm)	Total Length (mm)	Number measured	Standard Length (mm)	Number measured
August 5	1.50 ± 0.624	0.95 ± 0.401	2.16 ± 0.684	3	0.83 ± 0.316	350
August 19	1.22 ± 0.400	0.70 ± 0.196	1.96 ± 0.644	6	0.74 ± 0.222	350
August 23	1.74 ± 0.608	1.01 ± 0.346	2.91 ± 1.160	18	0.83 ± 0.261	350
August 28	1.64 ± 0.523	1.03 ± 0.307	2.81 ± 1.025	51	0.74 ± 0.200	350
September 6	1.40 ± 0.563	0.95 ± 0.390	2.38 ± 1.107	343	0.79 ± 0.253	350

DISCUSSION

Sampling results from May 2002 to September 2002 revealed that *D. lumholtzi* was only present during August and September samples collected from Harlan County Reservoir. Our sampling was terminated after 6 September 2002; thus, information on persistence of *D. lumholtzi* in the assemblage through the fall is not available. Studies conducted in Missouri and Kansas found similar results with *D. lumholtzi* only occurring during August through October (Havel and Herbert 1993, Dzialowski et al. 2000). In Illinois, *D. lumholtzi* populations peaked in June and July with a small peak in August and no *D. lumholtzi* observed in September or October (Kolar et al. 1997). On the border of Oklahoma and Texas *D. lumholtzi* populations peaked in early July with small numbers present through October (Work and Gophen 1999). These differences between studies might be explained by water temperature because *D. lumholtzi* reproduces more quickly at warmer

temperatures (Work and Gophen 1999, Lennon et al. 2001). Water temperatures during the period when *D. lumholtzi* was present ranged between 22.9 and 25.1° C for all stations (Table 2).

Our samples revealed increasing relative abundance of *D. lumholtzi* with the highest population density (2.17 ± 3.104 l^{-1}) found on the last sampling date. During the station samples of 5 August 2002, *D. lumholtzi* made up 0.1% of the total sampled *Daphnia* population with the native *D. retrocurva* accounting for 99.7%. However, a shift in *Daphnia* community structure was observed during the month of September as *D. lumholtzi* increased to 42.7% of the total *Daphnia* community (Table 1; Fig. 3). Based on this community trend, *D. lumholtzi* was probably the most abundant *Daphnia* species in late September in Harlan County Reservoir. This change in the composition of the *Daphnia* assemblage in Harlan County Reservoir could be the result of competition between species, selective fish predation on native species, or natural population declines in native species from abiotic factors (Dzialowski et al. 2000).

Daphnia lumholtzi is larger than most native species throughout its North American range (Lennon et al. 2001). Measurement of the Harlan County Reservoir population indicated that there were substantial differences in *D. lumholtzi* lengths during 5 August 2002 through 6 September 2002. During the period when *D. lumholtzi* was most abundant (6 September 2002), the smallest *D. lumholtzi* had a total length of 0.80 mm and the largest length was 5.66 mm. The only native species, which occurred in large numbers, was *D. pulicaria* that was approximately half the size of *D. lumholtzi* (Table 2). Our results for *D. lumholtzi* coincided with a study by Sorensen and Sterner (1992), who found maximum total lengths of 5.6 mm. Muzinic (2000) found total lengths of *D. lumholtzi* from the Great Lakes to range between 4.9 and 5.7 mm in length during August.

In our study, body lengths also were taken and results showed that body length ranged from 0.7 mm to 1.03 mm with a mean of 0.95 ± 0.39 mm during September. These results are different than the results found by Sorensen and Sterner (1992), who found a greater maximum body length of 1.8 mm. These measurements suggested that in Harlan County Reservoir the *D. lumholtzi* have relatively larger spines and smaller bodies than those observed by Sorensen and Sterner (1992) for populations from Texas. In our study, standard length measurement results ranged from 1.21 mm to 1.73 mm with mean of 1.40 ± 0.56 mm during September. These standard length measurements were similar to a study conducted by Swar and Fernando (1979), who found standard length measurements of *D. lumholtzi* ranging from 0.7 mm to 1.75 mm for *D. lumholtzi* within its native range in Nepal. Differences among populations should be examined to determine if they are caused by founder effects from establishment in new water bodies, or if the differences are caused by biotic and abiotic factors.

Daphnia lumholtzi's dispersal within North America reservoirs might occur through recreational boating from initially infested reservoirs to nearby reservoirs

(Havel and Hebert, 1993), or by non-human dispersal mechanisms such as waterfowl, wind, flowing water, and fish dispersing the resistant eggs (Dodson, 1992). A study conducted by Stoeckel et al. (1996) concluded that Midwestern river systems might serve as "dispersal highways" for *D. lumholtzi*, allowing them to drift or be transported to uninhabited areas throughout North America. While all the above methods are possible, the mechanism for *D. lumholtzi*'s establishment into Harlan County Reservoir is still uncertain. Dzialowski et al. (2000) concluded that most dispersal events in Kansas were attributed to recreational boating. Research currently is being conducted to determine *D. lumholtzi* presence in other Nebraska reservoirs on the Republican River Drainage (B. Peterson, unpublished data).

The impact of *D. lumholtzi* on native zooplankton communities is not known. However, *D. lumholtzi* has the potential to disrupt the structure of native zooplankton communities (Havel et al., 1995). As part of an ongoing study of Harlan County Reservoir, the feeding preference of gizzard shad (*Dorosoma cepedianum*), a food fish for walleye (*Stizostedion vitreum*) and white bass (*Morone chrysops*), is being examined to determine if their diet contains *D. lumholtzi*. One possibility is the large size of *D. lumholtzi* spines prevents small planktivores from eating it (Havel et al. 1995). Other studies should be implemented to determine the impacts *D. lumholtzi* might have on zooplankton and fish communities in Harlan County Reservoir and other irrigation reservoirs.

ACKNOWLEDGMENTS

We thank Carmen Heuton and Melissa Christ for helping with the zooplankton identification and measuring. We also thank the University of Nebraska at Kearney and the Nebraska Game and Parks Commission for technical support. Our research project F-160-R, was funded under the Federal Aid in Sport Fish Restoration Program.

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Received: 24 December 2003 *Accepted: 26 May 2005*

Comparison of Microclimate at Grassland Bird Nests with Different Substrates

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ABSTRACT -- We compared the effects of two different nest placement strategies (shrubs vs. bunchgrasses) on microclimate conditions for grasshopper sparrow (*Ammodramus savannarum*) and lark sparrow (*Chondestes grammacus*) in Oklahoma. We predicted that the intensity and duration of extreme temperatures (greater than 39° C) and their variability would be reduced at shrub nests compared to bunchgrass nests. Average maximum temperatures were similar at nests of grasshopper sparrow and lark sparrow, but confidence intervals were more variable and included biologically detrimental temperatures at grasshopper sparrow nests compared to lark sparrow nests. The proportion of time greater than 39° C also was similar at nests of both species, but on average grasshopper sparrow nests exceeded 39° C for 1.2 hr compared to 2.6 hr per 29-hr sampling period for lark sparrow nests. Our results indicate shrub nesters (lark sparrow) might be able to moderate the intensity and duration of biologically detrimental temperatures at their nests more successfully than bunchgrass nesters (grasshopper sparrow).

Key words: *Ammodramus savannarum*, *Chondestes grammacus*, grasshopper sparrow, lark sparrow, nest placement strategies, microclimate.

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Nest-site selection is a process that affects reproductive outcomes and, ultimately, population dynamics in birds. Understanding nest placement strategies for grassland birds in light of continued population declines is needed (Herkert and Knopf 1998, Sauer et al. 2001). Throughout their respective ranges, grasshopper sparrow (*Ammodramus savannarum*) and lark sparrow (*Chondestes grammacus*) populations have been declining over the past three decades (Sauer et al. 2001). Although these declines have often been attributed to high rates of nest failure due to predation (Ricklefs 1969), other authors have suggested that microclimate conditions might be a major selective pressure (Wiebe and Martin 1998, Lusk et al. 2003).

With and Webb (1993) proposed the Microclimate Selection Hypothesis to account for patterns of nest-site selection in grassland birds. The Microclimate Selection Hypothesis states that females should select nest sites that minimize stress induced by extreme weather conditions. According to the Microclimate Selection Hypothesis, extreme temperatures should occur less often and last shorter durations at nests compared to random points. The authors evaluated their hypothesis by determining the effects of wind breaks and radiative cover on nest-site selection for three grassland bird species with different nest-placement strategies. Their results indicated that species that nested in shrubs or bunchgrasses like lark bunting (*Calamospiza melanocorys*) were shaded at least three times longer during the hottest portion of the day than species like McCown's longspur (*Calcarius mccownii*) that built exposed nests. In an extension of this hypothesis, we suggest shrub nesters will be more likely to minimize exposure to extreme temperatures than bunchgrass nesters because of the choice of nest sites. Although we were not able to detect differences in nest vegetation structure or composition on our site (Suedkamp 2000), grazing or other management practices on other sites might allow maintenance of optimal microclimate conditions by manipulating vegetation.

We investigated the effects of nest placement strategy on the resulting microclimate for two species of grassland birds. Although both species are ground nesters, grasshopper sparrow usually place their nests in clumps of grass, leaves, or litter (Patterson and Best 1998, Vickery 1996), whereas lark sparrow typically nest at the base of shrubs supported by branches (Baepler 1968). Both species are small passerines that are primarily monogamous and ground foragers, although lark sparrow tends to be more granivorous than the grasshopper sparrow (Ehrlich et al. 1998). We predicted that the intensity (maximum temperature) and duration (proportion of time greater than or equal to 39° C) of critical temperatures would be reduced and less variable at shrub nests (lark sparrow) compared to bunchgrass nests (grasshopper sparrow). We used 39° C as the critical threshold for biologically detrimental temperatures because it approximates the point at which heat gain exceeds heat dissipation, concordant with reported upper thermal tolerance limits for optimal survival in embryo and adult birds (Webb 1987).

METHODS

We conducted research at the Marvin Klemme Experimental Range Research Station (35°25'N, 99°05'W) located in Washita County, Oklahoma, during the breeding seasons of 1999 and 2000. The study site is classified as southern mixed-grass prairie (Coupland 1992) and included three experimental grazing treatments: no grazing (greater than 50 years), moderate grazing (0.2 animal units/ha), and heavy grazing (0.4 animal units/ha). However, previous analyses showed no effects of grazing on vegetation structure or composition at nests, so data were pooled across grazing treatments within a species (Suedkamp 2000).

We searched for nests from May through July in 1999 and 2000 by using systematic searches combined with walking haphazard paths. The majority of nests were found by walking close to a nest and force-flushing the incubating or brooding female. Nests were monitored every 3 to 4 days to determine a fate. We estimated the timing of nest initiation by assuming the nesting period was 20 days for grasshopper sparrow and 21 days for lark sparrow (Baicich and Harrison 1997).

Between May and July of 1999 and 2000, we recorded temperatures at a subset of recently inactive nests by using HOBO data loggers (Onset Computer Corporation, Pocasset, Massachusetts). Although nests might have become inactive up to two weeks prior to sampling, we elected to use inactive nests to minimize potential negative effects on nesting pairs. Sampling periods in 1999 were 20 to 21 May, 19 to 20 June, and 14 to 15 July. Sampling periods in 2000 were 19 to 20 May, 19 to 20 June, and 12 to 13 July. We constructed wooden shields that allowed air flow for each datalogger but prevented direct solar radiation as suggested by the manufacturer, and reduced equipment damage due to trampling by cattle (*Bos taurus*). As part of larger study on several other species, we had eight data loggers that we randomly allocated among nests of all species, including our two focal species, in the three grazing treatments. For nests, we placed the datalogger enclosed in a wooden shield at the nest entrance for comparison. Dataloggers were programmed to record temperature readings every 5 seconds over two consecutive days each month that began at 1100 hr on the first day and concluded at 1600 hr on the second day for a 29-hr sampling period. In 1999, we monitored two grasshopper sparrow nests in May and one nest in June. In 2000, we monitored three grasshopper sparrow nests and two lark sparrow nests in May, one grasshopper sparrow nest and three lark sparrow nests in June, and one grasshopper sparrow nest and two lark sparrow nests in July.

We used bootstrap analysis without replacement and 95% confidence intervals to test for significant differences between maximum temperatures (° C) and the proportion of time greater than 39° C at lark sparrow compared to grasshopper sparrow nests (Mooney and Duval 1993). We generated 1,000 bootstrap estimates for the mean of each variable at nests of both species by using SYSTAT ver. 8.0

(SPSS 1998). We used bootstrapping because we had small sample sizes and were unwilling to make stringent assumptions about the distribution of sample parameters, which are required by many of the more traditional statistical methods (Mooney and Duval 1993).

RESULTS

The majority of grasshopper sparrow nests located during the breeding season (68%, n = 15) were placed in bunchgrasses and the remaining nests (32%, n = 7) were placed in shrubs. With one exception, most lark sparrow nests (n = 42) were located at the base of broom snakeweed (*Gutierrezia sarothrae*) supported by branches. Peak times of estimated nest initiation were in late May for grasshopper sparrow and late May to early June for lark sparrow (Fig. 1). Raw nest success was 23% and 29%, respectively for grasshopper sparrow and lark sparrow. Average maximum temperatures at the subset of nests of lark sparrow (37.8° C ± 0.03 SE; 95% CI 36.0 - 39.8) monitored were similar to grasshopper sparrow (40.3° C ± 0.04 SE; 95% CI 38.0 - 42.6), but the confidence intervals were wider and included biologically detrimental temperatures (those greater than 39° C) at grasshopper sparrow nests. The average proportion of time greater than 39° C also was similar at the subset of monitored lark sparrow nests (0.04 ± 0.00 SE; 95% CI 0.00 - 0.09)

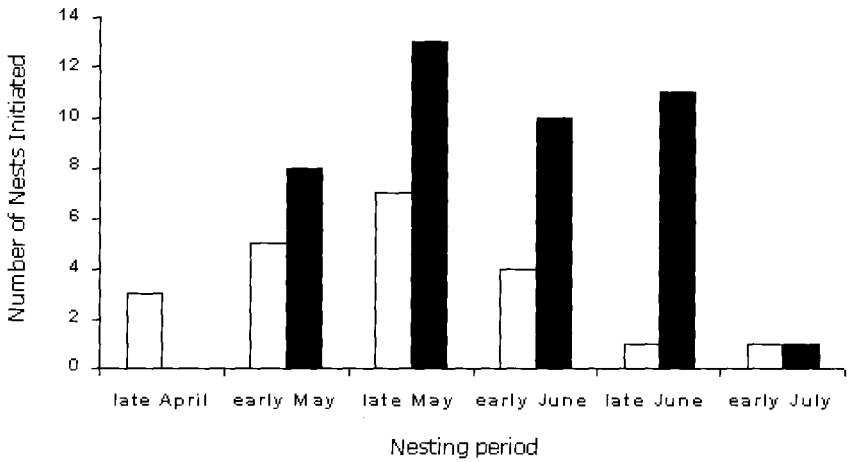

Figure 1. Nest initiation chronology of grasshopper sparrow (open bars; n = 22) and lark sparrow (solid bars; n = 43) by two-week period during the breeding seasons of 1999 and 2000 in Oklahoma.

and grasshopper sparrow nests (0.09 ± 0.00 SE; 95% CI 0.03 - 0.15), but on average lark sparrow exceeded 39° C for 1.2 hr per 29-hr sampling period compared to 2.6 hr at grasshopper sparrow nests. Greater variability in maximum temperatures and the proportion of time greater than 39° C, as indicated by the width of the confidence interval and sampling distribution (Fig. 2), showed that grasshopper sparrow might be less successful at moderating nest microclimate in bunchgrasses than lark sparrow that nest in shrubs.

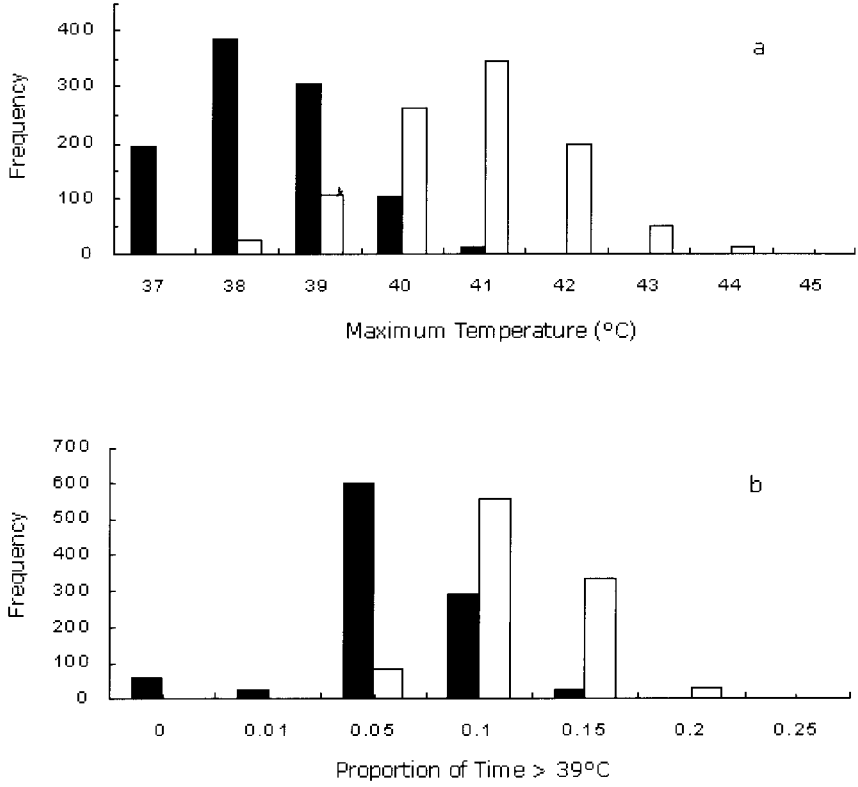

Figure 2. Distribution of 1,000 bootstrap means for (a) average maximum temperature (°C) and (b) the proportion of time greater than 39°C for lark sparrow nests (solid bars; n = 11) and grasshopper sparrow nests (open bars; n = 11).

DISCUSSION

Although our results were not statistically significant, we suggest they might represent biological trends. Greater variation in maximum temperature and the proportion of time greater than 39° C at grasshopper sparrow nests compared to lark sparrow nests might have been a result of small sample sizes, but our bootstrap analysis provides evidence that sampling artifacts might not be the best explanation. Instead, we suggest our analysis shows that selection for nest sites that minimizes temperatures greater than 39° C might not have been necessary for grasshopper sparrow due to their nesting chronology. Our larger data set including all grasshopper sparrow nests found shows that peak nest initiation is in late May (Fig. 1) when ambient temperatures never exceeded 33° C during our sampling periods in either year (Suedkamp 2000). As a result, grasshopper sparrow actually might be selecting warmer nest sites to maintain optimal incubation temperatures (Webb 1987) early in the breeding season. Although mean trends in our data only provide circumstantial support for this theory, the selection of nest sites near bunchgrasses might be connected with selection for warmer nest sites early in the breeding season due to thermal benefits accruing from direct solar radiation.

Conversely, selecting nest sites near shrubs might be necessary for lark sparrow because peak nest initiation is later in the summer (Fig. 1) when ambient temperatures begin to exceed upper critical thresholds. For example, Lusk et al. (2003) identified woody cover as a key factor influencing nest-site selection in lark sparrow and attributed it to the potential for thermal protection. High selectivity of nesting sites near shrubs in this species might be reflective of the increased potential for thermal moderation in shrubs compared to bunchgrasses. For example, our data showed that the upper end of the confidence interval for maximum temperature at nests of lark sparrow is about 3° C lower than at grasshopper sparrow nests. Although it is possible that 3° C does not represent a biologically meaningful increase for short periods of time, the width of confidence intervals around the proportion of time greater than 39° C and the distribution of bootstrap means (Fig. 2) showed extreme temperatures persisted twice as long at grasshopper sparrow nests compared to lark sparrow nests. If this difference is sufficient to reduce potential effects on survival and reproduction, this would represent a biologically meaningful pattern in nest-site selection. Although we did not assess survivorship or cumulative reproductive efforts, evidence reviewed by Webb (1987) showed limited exposures (minutes to hours) within the ranges we observed have been associated with detrimental effects. Some of the documented effects include a reduction in breeding activity, shortening of the breeding season, (Guthery et al. 2001), cardiac and respiratory failure, and ultimately decreased survival in birds of all developmental stages (Webb 1987).

In conclusion, we suggest that we have observed biologically meaningful trends in nest-site selection for ground-nesting grassland birds that merit further evaluation. Our evidence indicated the choice of nest site might be related to nesting chronology. Further work investigating the potential of extreme temperatures to influence nest-site selection patterns is needed. Efforts to link survival and reproductive outcomes with nest sites and the resulting thermal profile at individual nests with larger sample sizes will be especially helpful.

ACKNOWLEDGMENTS

We thank M. Ryan, J. Lusk, F. Guthery, and S. Allen for providing comments on earlier drafts that improved the manuscript. Funding was provided by the Bollenbach Endowment, the Game Bird Research Fund, and the Noble Foundation at Oklahoma State University. M. Bahm, W. Harrell, A. Burrow, and J. Wells provided field assistance. Our paper was approved for publication by the Oklahoma Agricultural Experiment Station.

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Received: 11 February 2004 *Accepted: 28 December 2004*

Associate Editor for Ornithology: Gregory A. Smith

Factors Influencing Persistence of White-footed Mice

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ABSTRACT -- We examined factors that potentially influenced persistence of the white-footed mouse (*Peromyscus leucopus*) during 1981 to 1988 at Konza Prairie Biological Station, Kansas. We predicted that both abiotic (e.g., precipitation and temperature) and biotic (e.g., availability of food and density of conspecifics) factors would influence persistence of individuals at the study site. Persistence of individual white-footed mice on the study site differed among years and seasons. White-footed mice that were first captured in summer or in autumn persisted longer than those first captured in spring. Young females (less than 20 g) had greater persistence than young males, whereas old males (greater than or equal to 25 g) had greater persistence than old females. Persistence of white-footed mice captured in summer, autumn, and spring was related to abundance of white-footed mice, to production of seeds by woody plants, and to precipitation during March-May, respectively. Ambient temperature had no influence on persistence. We suggest that biotic and abiotic factors that influence persistence of white-footed mice are local in scale and that they affect persistence differentially at different times of the year.

Key words: *Peromyscus leucopus*, persistence, survival, white-footed mouse.

Food has been suggested as a limiting resource that affects density and dynamics of populations and population-level processes of small mammals. Generally, densities of small mammals are related directly to availability of food (Boutin 1990). Increases in abundance of small mammals related to increased quantities of food should result from immigration, reproduction, and increased

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survival. Densities of the white-footed mouse (*Peromyscus leucopus*) in spring and summer were correlated positively with availability of food, primarily mast, during the previous winter (Miller and Getz 1977, Hansen and Batzli 1979, Wolff 1989, Kaufman et al. 1995, Elkington et al. 1996, Ostfeld et al. 1996, Wolff 1996, Jones et al. 1998). Increased densities in spring and summer resulted from increased reproduction and earlier onset of reproduction (Hansen and Batzli 1978, Hansen and Batzli 1979, Wolff 1996, Jones et al. 1998). In addition, Jones et al. (1998) asserted that white-footed mice have greater over-winter survival in mast years, but provided no supportive data. In support of greater survival, Wolff (1993) found more old white-footed mice in his study population in two of three springs following autumns with large mast crops.

No consistent relationship between survival and availability of food is evident for small mammals (Boutin 1990), especially white-footed mice. Survival of adult white-footed mice increased (e.g., Bendell 1959, Wolff 1993), decreased (e.g., Hansen and Batzli 1978, Briggs 1986), or remained unchanged (e.g., Blair 1948, Hansen and Batzli 1979, Briggs 1986, Wolff 1986) in response to experimental supplementation of food or a superabundance of natural foods. The lack of a consistent pattern of survival in response to food suggests that other biotic or abiotic factors must be involved.

Biotic factors, other than food, that influence survival of individual white-footed mice include abundance of conspecifics (Rintamaa et al. 1976, Miller and Getz 1977) and sex or age of individuals (Snyder 1956, Adler and Tamarin 1984, Millar 1984, Schug et al. 1991). Abiotic factors that might influence survival in the white-footed mouse and other terrestrial small mammals include ambient temperature and amount of precipitation (Lewellen and Vessey 1998). For example, extreme temperatures in winter and summer might thermally stress mice, whereas drought and flooding might cause direct mortality or alter quality of the habitat. Except for flooding (Batzli 1977), we found no studies that have examined the influence of abiotic factors on survival of white-footed mice, probably because collection of long-term data generally is needed to discern such patterns.

Long-term studies are essential to examine processes that have high annual variability (Franklin 1989). Demographic characteristics of populations of white-footed mice and other small mammals typically have high inter-annual and intra-annual variability, especially in temperate regions (Sexton et al. 1982, Tilman 1989, Krohne and Burgin 1990, Lewellen and Vessey 1998). However, the vast majority of demographic analyses of small mammals have been for short-term studies (less than three years). Short-term approaches might be misleading due to rare or episodic events (e.g., disease, wildfire, and extremes in precipitation, temperature, and production of seeds; Franklin 1989, Tilman 1989). Variability in response variables due to a range of variation in environmental factors typically is considered as noise in short-term studies; however, long-term approaches enable the use of patterns of environmental variability to suggest causal relationships in nature.

In 1981, we initiated a study to assess temporal variability in abundance of white-footed mice in forested habitats on the Konza Prairie Biological Station in northeastern Kansas. The magnitude of temporal variation in abundance of white-footed mice at that site (Kaufman et al. 1995) was typical of variation observed in other populations of the white-footed mouse (e.g., Krohne et al. 1988, Krohne and Burgin 1990, Wolff 1996, Lewellen and Vessey 1998). Our seasonal monitoring of abundance of white-footed mice precluded any assessment of mortality and dispersal, but there is little dispersal by adult white-footed mice (Burt 1940) and we could examine length of persistence of individuals on the study site. We hypothesized that factors influencing abundance also would influence persistence. That is, we predicted that precipitation, availability of food (primarily mast production in autumn), and density of conspecifics would influence persistence. More specifically, we expected that persistence of adult white-footed mice would be related positively to production of mast and negatively to density and that precipitation could have either a positive or negative effect on persistence.

MATERIALS AND METHODS

We sampled small mammals at a wooded site from autumn 1981 to spring 1988 on Konza Prairie Biological Station near Manhattan, Kansas (detailed description in Kaufman et al. 1995). Woody habitats in this region of the tallgrass prairie are sparse and typically associated with streams or rocky outcrops formed by exposed layers of limestone. Therefore, the woody habitats are narrow strips of woodland bordered by native tallgrass prairie on the sides. We established four traplines to sample the linear habitats along the south fork of the King's Creek drainage (T11S, R8E, SW1/4 Section 18, Riley County). Two lines were in gallery forest associated with an ephemeral stream and two were along adjacent limestone outcrops. All traplines were located within an area of about 1 km^2 and likely were sampling the same population of white-footed mice. Woody vegetation associated with limestone outcrops was rough-leaved dogwood (*Cornus drummondii*), redbud (*Cercis canadensis*), smooth sumac (*Rhus glabra*), aromatic sumac (*R. aromatica*), and bur oak (*Quercus macrocarpa*), whereas gallery forest was dominated by bur oak, chinquapin oak (*Q. muhlenbergii*), hackberry (*Celtis occidentalis*), American elm (*Ulmus americana*), and buckbrush (*Symphoricarpos orbiculatus*).

Each trapline consisted of 20 stations with a 15-m interval between stations. Two large Sherman live-traps (7.6 x 8.9 x 22.9 cm) were placed at each station. We simultaneously sampled small mammals on all traplines for four consecutive nights during summer, autumn, and spring of each year (autumn 1981-spring 1988). Summer, autumn, and spring samplings typically were conducted in July, October, and March, respectively. At first capture, all

individuals were toe-clipped with a unique number. Species, age based on coloration of pelage, sex, mass to the nearest 0.5 g, and reproductive condition were recorded for each capture during each sampling period. At initial capture, each individual was assigned to a body mass category that was related roughly with age (Hansen and Batzli 1978, Wolff 1993, McMillan et al. 1997). Categories of body mass were less than 20.0 g (juveniles and subadults), 20.5 to 25.0 g (young adults), and 25.5 to 30.0 g and greater than 30 g (combined to comprise old adults). Sampling years were from summer through the following spring (e.g., sampling year 1982 consisted of summer 1982, autumn 1982, and spring 1983) as this corresponded to the growing season for vegetation; spring sampling occurred before vegetation began to grow.

Herein, we will use the term persistence to refer to length of time individuals remained in the population. We defined persistence as the number of sampling periods that each individual white-footed mouse was present at our site. Animals captured for the first time during sample-year 1987 (last year of the study) were excluded from analyses of persistence because we did not know how long individuals remained on the sites after the study ended. Because all traplines were sampling the same population, we pooled data from all four traplines and used the individual mouse as the experimental unit.

Production of seeds in gallery forest was estimated by Briggs et al. (1989) concurrent with our small mammal study. Open-topped collectors (0.25 x 0.25 x 0.50 m) collected particulate matter greater than 1 mm^2 and were open at 1 m above the forest floor (Briggs et al., 1989). Sixty collectors were placed at random locations in the gallery forest in September 1981 (Briggs et al. 1989). Trapped litter was collected at least monthly for the duration of the study. Amount of seed fall (g/m^2) was calculated for April to September and October to March from October 1981 through March 1988. Mean values of seed fall used for our analysis (taken from Briggs et al. 1989) were 2, 6, 28, 22, 5, and 17 g/m^2 during April to September from 1982 to 1987, and was 22, 12, 17, 1, 23, 3, and 38 g/m^2 during October to March from 1981/82 to 1987/88.

We obtained climatic data from the Kansas Agricultural Experiment Station for Manhattan, which is located about 15 km north of our study area. Mean annual precipitation during our study was 91.2 ± 7.2 cm ($\bar{x}$ ± SE), which is slightly higher, but consistent with the 50-year mean (83 cm). Annual precipitation during the study ranged from 51.3 to 112.3 cm. Likewise, the range of seasonal precipitation also was high (spring: 27.3 to 39.8 cm; summer: 14.5 to 43.7 cm; and winter: 14.5 to 48.0 cm). Mean annual temperature was 13.0 ± 0.2° C and ranged from 11.7 to 14.2° C during our study. Range of mean temperatures within a season among years was similar (spring: 4.7 to 7.7° C; summer: 18.1 to 20.0° C; and winter: -8.0 to -3.8° C). Amounts of precipitation and temperatures used in our analyses were summarized in Kaufman et al. (1995).

We used analysis of variance (PROC GLM; SAS Institute, Inc. 1988) to test for effects of and interactions among season, year, and sex and body mass

categories on persistence. To avoid pseudoreplication (Hurlbert 1984), we used only data from initial capture of each individual for our analysis.

We used multiple-regression analyses to test for relationships between mean persistence of individuals and abiotic and biotic factors. Abiotic and biotic factors considered for analysis of persistence of summer-captured white-footed mice were mean minimum temperature, mean maximum temperature, mean temperature of the warmest month, overall mean temperature, precipitation during June to August, abundance of white-footed mice during the summer sampling period, and seed fall during April to September. Similarly, factors considered for analysis of persistence of autumn-captured white-footed mice were average minimum temperature, average maximum temperature, average temperature of the coldest month, overall average temperature, precipitation during December-February, abundance of mice during the autumn sampling period, and seed fall during October-March. For analysis of persistence of spring-captured white-footed mice, factors considered were mean minimum temperature, mean maximum temperature, mean temperature of the coldest month, overall mean temperature, precipitation during March to May, abundance of white-footed mice during the spring sampling period, and seed fall during both October to March and April to September. For multiple-regression analyses, we used all individuals captured during each season instead of only mice first captured during a given season for our seasonal analyses.

Most white-footed mice captured during our study were present only for one or two sampling periods. Moreover, few white-footed mice (less than 6%) persisted on our sites for greater than or equal to one year (McMillan et al. 1997); therefore, we assumed that values for seasonal persistence among years (e.g., summer 1981 versus summer 1982) were independent. In addition, we hypothesized that factors influencing persistence were not continuous throughout the year. If factors influencing persistence did change within a year, then even our seasonal sampling periods were independent. Our results are presented as $\bar{x} \pm$ SE and level of significance for all tests was P less than or equal to 0.05.

RESULTS

Individual white-footed mice (n = 866) persisted, on average, 0.62 ± 0.004 sampling periods after their initial capture. Variability in persistence was great as some individuals were captured only during the initial sampling period, whereas others were captured for up to nine consecutive sampling periods (McMillan et al. 1997). Two temporal factors that significantly influenced persistence of individuals included season of first capture ($F = 6.81$, d.f. = 2, 849, $P \leq 0.01$) and year of first capture ($F = 4.84$, d.f. = 5, 849, $P \leq 0.01$). Persistence values of mice first captured in summer (0.75 ± 0.07) and autumn, (0.64 ± 0.05), which did not differ, were greater than for those individuals first captured in spring (0.45 ± 0.07). The mean time

intervals between sampling periods were not equal (summer to autumn, autumn to spring, and spring to summer intervals were 3.5, 4.5, and 4 months, respectively). When persistence values were adjusted for differences in interval between sampling periods, results were not different from non-adjusted values. The mean persistence of individual white-footed mice ranged from a low of 0.34 ± 0.13 sampling periods in 1984 to a high of 0.81 ± 0.08 sampling periods in 1985.

Persistence of autumn-captured mice varied significantly among years with a low of 0.26 ± 0.16 sampling periods in 1984 and a high of 0.87 ± 0.11 sampling periods in 1985 ($F = 3.58$, d.f. = 5, 398, $P \leq 0.01$). Persistence of mice captured in spring and summer exhibited similar yearly patterns of variation, but these patterns were not significantly different among years for either season.

Sex and body mass of individuals at first capture interacted to significantly influence persistence such that persistence differed significantly between female and male white-footed mice in different categories of body mass (Fig. 1; $F = 3.63$, d.f. = 3, 849, $P \leq 0.05$). Specifically, small females (less than or equal to 25 g) persisted on our study sites longer than small males, whereas large males (greater than 25 g) persisted longer than large females (Fig. 1).

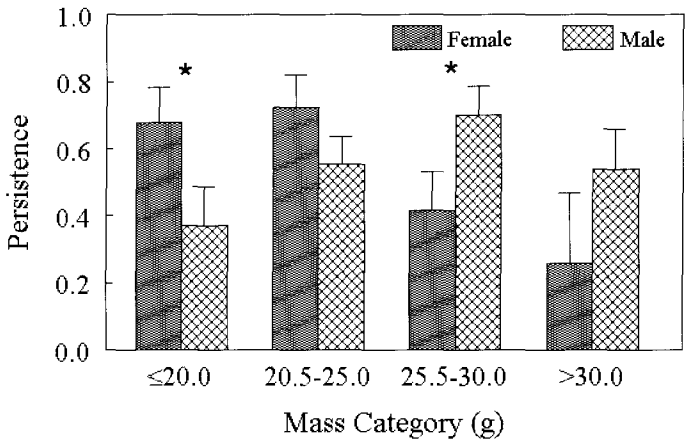

Figure 1. Mean persistence (± SE) of male and female white-footed mice (*Peromyscus leucopus*) in woody habitats on Konza Prairie Biological Station, Manhattan, Kansas during 1981 to 1988. Individuals were assigned to body mass categories based on mass at first capture. Values of persistence represent the number of sampling periods that individual white-footed mice were present on study sites after initial capture (1 is equal to about 4 months). An asterisk indicates a significant difference between persistence of female and male white-footed mice at $P \leq 0.05$.

Persistence of individual white-footed mice captured during our seasonal sampling periods was related to only one of the many abiotic or biotic factors examined during each season and the factor related to persistence differed among seasons. Persistence of individual white-footed mice first captured during summer was related negatively to abundance during the same sampling period ($R^2 = 0.70$, d.f. = 5, $P \leq 0.05$). Overwinter persistence of white-footed mice first captured during autumn was related strongly and positively to seed fall during October to March ($R^2 = 0.96$, d.f. = 5, $P \leq 0.01$). Persistence of individual white-footed mice first captured during spring was related negatively to amount of precipitation during March to May ($R^2 = 0.65$, d.f. = 5, $P \leq 0.05$).

DISCUSSION

White-footed mice typically were present for only one or two sampling periods (less than one year), a pattern that was consistent with past studies (Blair 1948, Snyder 1956, Miller and Getz 1977, Schug et al. 1991). Persistence varied greatly among individuals as a few white-footed mice were present for one to two years (four to seven sampling periods) and one male remained for greater than three years (nine sampling periods; McMillan et al. 1997). Further, persistence varied significantly among years and seasons, which also was consistent with past studies of white-footed mice (Blair 1948, Snyder 1956, Miller and Getz 1977, Schug et al. 1991).

Persistence of individuals first captured during spring was significantly lower than for those first captured during summer or autumn. This difference likely resulted from dispersal of young during late spring and early summer (Burt 1940, Goundie and Vessey 1986). Further, persistence in spring was related negatively to amount of precipitation in spring. One possible explanation for this pattern is that white-footed mice likely were more active aboveground during this time; young mice were dispersing, adult males were searching for mates, and adult females were meeting higher energetic demands of reproduction. White-footed mice would be more exposed to extreme environmental conditions and potentially could experience higher mortality when the amount of precipitation is high than when it is low. Possibly deaths, dispersal, or both caused by flooding of belowground burrows were greater during springs with high precipitation than in those springs with low precipitation.

Persistence of females and males differed among categories of body mass. Small females persisted longer on our site than did small males. This difference likely was caused by differences in dispersal tendencies between the two groups; that is, young males are more likely to disperse and move greater distances than young females (Burt 1940, Krohne et al. 1984, Wolff 1985, Goundie and Vessey 1986, Wolff 1989, Keane 1990). However, in contrast to both Wolff (1985) and

Miller and Getz (1977), but consistent with Adler and Tamarin (1984), intermediate-sized and large males persisted longer than females of similar sizes. Little dispersal is thought to occur after establishment of residency by males and females (Burt 1940, Goundie and Vessey 1986), a pattern that is inconsistent with differential persistence among adult males and females. We suggest that decreased persistence by large females might be due to higher mortality that results from higher cost of reproduction for females as compared to males (Wolff 1989).

White-footed mice captured during summer persisted for less time when summer abundance was high than when it was low. This relationship was consistent with a trend for a high level of dispersal by adults when densities are high and vice versa (Krohne et al. 1984). However, this pattern was apparent only for persistence of our summer-caught white-footed mice and not for spring or autumn-caught white-footed mice. If persistence were related directly to density, we would expect the highest relationship to occur in the season with the highest densities of white-footed mice, which was autumn. One possible cause for the persistence-density relationship in summer, but not in autumn, might be related to a greater likelihood of natal dispersal in summer than autumn; young white-footed mice present in autumn often overwinter in the natal den and disperse in spring (Wolff and Durr 1986). Additionally, mortality due to predation might be higher in summer than winter (*P. maniculatus*; Kaufman 1990), but we have no observations from our study site to support this conjecture.

Persistence of white-footed mice captured in autumn was related to seeds produced in forested habitats during October to March. Differences in seed production explained 96% of the variability in persistence of autumn-captured mice. Consistent with the observed effect of food on persistence in autumn, abundance of white-footed mice in spring on our sites was related positively to amount of seed fall from the previous October to March period (Kaufman et al., 1995). However, we found no relationship between seed fall in October to March and persistence of spring-captured white-footed mice. The increased abundance during summers following mast years (Ostfeld et al. 1996, Jones et al. 1998) likely is due to both increased abundance in spring (Kaufman et al. 1995) and increased reproduction in spring (Hansen and Batzli 1978, Hansen and Batzli 1979, Wolff 1996, Jones et al. 1998), but not directly related to autumn mast.

From our results, it seems probable that studies examining effects of supplemental food on persistence of white-footed mice at different times of the year would yield differing results as has been the case. For example, supplemental food applied during April to October likely would not increase persistence when natural foods are abundant. In contrast, supplemental food supplied during November to March likely would increase persistence during periods of low levels of natural foods. Consistent with these predictions, persistence of adult white-footed mice either was unaffected or decreased when food was supplied from spring to autumn (Blair 1948, Hansen and Batzli 1978, Briggs 1986, Wolff 1986). Further, the only study that supplemented food

to over wintering populations of white-footed mice found a corresponding increase in the persistence of individual adults (Bendell 1959).

Multiple factors influenced overall persistence of white-footed mice on Konza Prairie, but our study suggested that one factor might predominate in its influence on persistence at any given time of the year. We acknowledge the oversimplification of this statement, but it might be instructive in furthering our understanding of conflicting results among studies. For example, studies that examine one factor (e.g., food, density, or precipitation) during one season within a single year or among several years might find a relationship with persistence, whereas studies using similar methods during other seasons might find none. Based on our data, the only abiotic factor of consequence was precipitation in spring, which was related negatively to persistence of individuals captured in spring. In contrast, biotic factors, such as abundance of white-footed mice and production of seeds in the gallery forest, were the factors that were related to persistence of summer-captured and autumn-captured white-footed mice, respectively. We suggest that factors that influence persistence of white-footed mice are local on a landscape level and vary on a temporal scale that is less than a year in length. Therefore, studies designed to examine factors expected to influence demographic characteristics, such as persistence and abundance in populations of small mammals, should be approached by assessing seasonal variation rather than on an annual basis.

ACKNOWLEDGMENTS

Our study was conducted on Konza Prairie Biological Station, a tallgrass prairie preserve owned by The Nature Conservancy and managed by the Division of Biology, Kansas State University. We thank E. J. Finck for collecting the small mammal data as part of his duties at Konza Prairie Biological Station. National Science Foundation Grants DEB-8012166 and BSR-8514327 provided support for our project. Our paper is contribution 05-264-J from the Kansas Agricultural Experiment Station, Kansas State University, Manhattan.

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Received: 9 July 2004 *Accepted: 11 May 2005*

Acting Associate Editor for Mammalogy: Elmer J. Finck

NOTES

RECORDS OF THE EASTERN RED BAT ON THE NORTHERN FRONT RANGE OF COLORADO -- Although common in deciduous forest throughout the Midwest and east-central states, the eastern red bat (*Lasiurus borealis*) is rare in Colorado (Armstrong et al. 1994, Fitzgerald et al. 1994). However, this species has the potential to extend its range because belts of eastern deciduous forest habitat have expanded across western prairies and reached the Front Range of Colorado over the last 100 years (Knopf 1986). The eastern red bat ranges from Canada southward across the United States to northeastern New Mexico with most records occurring east of the Continental Divide (Hall 1981, Shump and Shump 1982, Cryan 2003). The historical range of the eastern red bat in Colorado extends along the riparian forest habitat of the South Platte and Arkansas rivers of eastern Colorado as far west as Boulder and Pueblo counties, respectively. Previous records of this species in Colorado are either individual animals caught incidentally or those submitted by the public to the Colorado Division of Public Health and Environment that lacked accurate location information (Armstrong et al. 1994). Everette et al. (2001) tentatively identified the presence of red bats on the outskirts of Denver, Colorado as recently as 2 and 7 July 1997, based on four echolocation calls recorded with Anabat detectors. Despite extensive mist netting, no red bats were captured. No new records have been reported for this species in Colorado since that time.

An adult female eastern red bat was captured at the Archery Range Natural Area along the Cache La Poudre River on the outskirts of Fort Collins, Colorado (40°32'N, 104°59'W) at 0029 hr on 31 July 2003. The non-reproductive bat weighed 19.5 g and had a forearm length of 42.8 mm. Photographs, body measurements, and blood and tissue samples were taken from the animal before it was released. The tissue sample and photographs will be archived at the Denver Museum of Nature and Science. On the same night, a second eastern red bat escaped from a mist net placed across Spring Creek at Hill Pond Natural Area (40°33'N, 105°5'W) in Fort Collins before it could be handled and processed (Roger Pearce, Colorado State University, Fort Collins, Colorado, personal communication). The eastern red bat is presumed to be migratory (Cryan 2003). Cryan (2003) used museum records to show the seasonal expansion of this species onto the northern Great Plains during August, which corresponds to the late-July date of our capture. Additional studies also have suggested that the eastern red bat migrates in late July and early August (Constantine 1966, Valdez et al. 1999). The bats noted here might have been behaving similarly. My colleagues and I mist netted approximately 60 nights in and around Fort Collins between 2001 and 2003 with no other captures of the eastern

red bat. The capture of one animal and observation of a second in the same evening suggest that eastern red bats might have been migrating through the area.

The documentation of the eastern red bat in Fort Collins is the first record for this species along the Cache La Poudre River, and is the northernmost location for the species in the state of Colorado. The eastern red bat might become more common in these areas as mature riparian forest continues to develop along rivers, canals, and other water diversions on the Front Range and adjacent prairies of Colorado.

I am grateful to J. Tharp, C. Newby, and M. Vrabely for assistance in the field and to the Fort Collins Natural Areas for providing access to their property. Captures of bats were made under authority of Colorado Division of Wildlife permit 03-TR738 and City of Fort Collins Natural Area permit 0311. I thank T. J. O'Shea and P. M. Cryan for their comments. – *Daniel J. Neubaum, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80526. E-mail address: dan_neubaum@usgs.gov*

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Received: 24 December 2003 *Accepted: 25 December 2004*

LACK OF BROWN-HEADED COWBIRD NEST PARASITISM IN A SHORT GRASS REGION -- While conducting field work in Morton County, southwestern Kansas and Baca County, southeastern Colorado, during the period 27 May to 2 July, 1997, we found 36 nests of seven bird species. Nests were not searched for systematically, but were found coincidentally as data were collected along transects during research investigating the breeding bird and plant communities of black-tailed prairie dog (*Cynomys ludovicianus*) colonies and noncolonized shortgrass prairie (Winter 1999).

The number of nests for each species and the contents of those nests were: mourning dove (*Zenaida macroura*) (n = 5 nests; 1, 2, 2 eggs/nest; 2, 2 chicks/nest); common nighthawk (*Chordeiles minor*) (n = 1 nest; 2 chicks/nest); horned lark (*Eremophila alpestris*) (n = 7 nests; 3, 4 eggs/nest; 1, 3, 4, 4 chicks/nest; 1 nest with both 2 eggs and 2 chicks); lark bunting (*Calamospiza melanocorys*) (n = 15 nests; 0, 1, 4, 4, 4, 5, 5, 5, 5, 5, 5, 6 eggs/nest; 1, 5, 5 chicks/nest); grasshopper sparrow (*Ammodramus savannarum*) (n = 3 nests; 0, 0, 5 eggs/nest); red-winged blackbird (*Agelaius phoeniceus*) (n = 2 nests; 4 eggs/nest; 1 nest with both 2 eggs and 2 chicks); and western meadowlark (*Sturnella neglecta*) (n = 3 nests; 1, 4, 5 eggs/nest). None of the nests contained brown-headed cowbird (*Molothrus ater*) eggs or young.

Study sites were pastures and black-tailed prairie dog colonies located on the Cimarron National Grassland and adjacent private land and encompassed a total area of approximately 1,269 ha. Cattle (*Bos taurus*) were present in most areas within the study landscape including many of the study sites. Cropland was adjacent to or near many of the study sites, but all study sites were contiguous with larger blocks of grassland vegetation. Vegetation of the study sites was characterized by the perennial shortgrasses *Aristida purpurea*, *Bouteloua gracilis*, and *Buchloe dactyloides*, and the perennial mid-height grass *Bouteloua curtipendula* (Winter et al. 2002). Vegetative structure in all study sites was characterized by relatively low values of height and visual obstruction (Winter et al. 2002).

Woody vegetation within the study sites was scarce to nonexistent, but when present was represented by shrubs and succulents such as *Baccharis wrightii*, *Chrysothamnus pulchellus*, *Gutierrezia sarothrae*, *Opuntia polyacantha*, and *Yucca glauca* (Winter 1999). Trees in the surrounding landscape were scarce and restricted to plantings around farmsteads. A riparian forest consisting of *Populus deltoides* and *Tamarix* spp. was present along the Cimarron River, greater than or equal to 4 km from the study sites. Habitat characteristics at nest sites were not quantified, but a qualitative assessment of lark bunting nest sites suggests that nests were preferentially placed at the base of prominent plants, especially *Cirsium ochrocentrum*, often with the previous years stem fallen down and partially covering the nest.

Shaffer et al. (2003) summarized the results of previous research on rates of brown-headed cowbird parasitism in grassland environments. Reported nest parasitism rates for the nesting species we found in our study, as reviewed by Shaffer et al. (2003), ranged from 0-60% for horned lark, 0-61% for lark bunting, 0-58% for grasshopper sparrow, and 7-46% for western meadowlark. Much of the research reviewed by Shaffer et al. (2003) indicated that nest parasitism rates in grassland environments can be influenced readily by the presence or absence of perch sites and the proximity of nests to woody edge habitats. The scarcity of woody vegetation and prominent perches in our study landscape might have been a contributing factor to the lack of nest parasitism.

However, density-dependent factors might ultimately determine brown-headed cowbird habitat selection and parasitism rates (Herkert et al 2003, Jensen and Cully, 2005). In regions of the Flint Hills of Kansas and Oklahoma where brown-headed cowbird densities were low, parasitism rates were related positively to the presence of wooded edge habitats; in regions of the Flint Hills with high brown-headed cowbird densities, parasitism rates were high in all habitats, showing no relationship to the density of hosts or the availability of perch-sites (Jensen and Cully, 2005).

Breeding Bird Survey data showed that the region encompassing our study area is characterized by relatively low densities of brown-headed cowbirds (Price et al. 1995). This is corroborated by the results of Winter et al. (2003). When avian relative abundance data were collected on transects within our study sites in 1996 (21 km of transects sampled) and 1997 (34.6 km of transects sampled) during May and June, only two brown-headed cowbirds were recorded out of a total of 1,362 individuals detected for all species (Winter et al. 2003).

Low densities of the brown-headed cowbird in our study region, which is characterized by a semi-arid climate, might be a consequence of host populations that exhibit extreme temporal and spatial variability in response to the climatic variability of these regions (Wiens 1974, Cody 1985, Winter et al. 2003). As host populations vary greatly in time and space over large areas on the western Great Plains (Wiens 1974, Cody 1985), perhaps the brown-headed cowbird is simply unable to effectively respond to host population changes. -- *Stephen L. Winter[1] and Jack F. Cully, Jr. U.S. Fish & Wildlife Service, San Luis National Wildlife Refuge Complex, Los Banos, CA 93635 (SLW). USGS-BRD, Kansas Cooperative Fish and Wildlife Research Unit, Kansas State University, Manhattan, KS 66506 (JFC). [1]E-mail address: Stephen_Winter@fws.gov*

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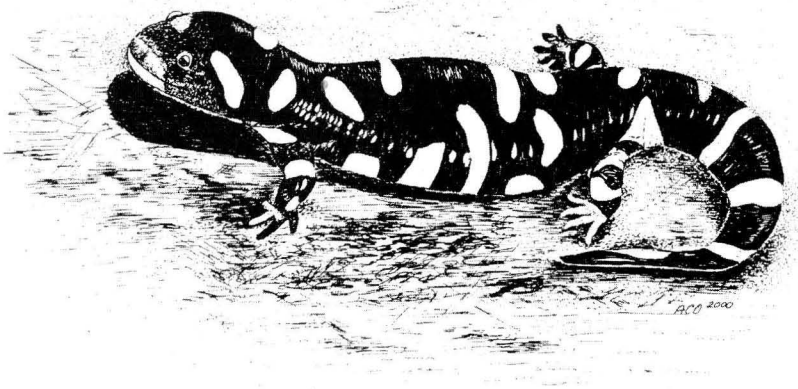
Received: 19 May 2004 *Accepted: 25 December 2004*

Associate Editor for Ornithology: Gregory A. Smith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ELECTROCUTION OF AN ADULT WHITE-TAILED DEER -- On 16 May 2002, an adult female white-tailed deer (*Odocoileus virginianus*) died after becoming entangled in an electric fence in southeast Minnesota. The deer (#393) was captured 30 January 2000 as part of a cooperative, long-term deer mortality study being conducted in southern Minnesota (Bigalke et al. 2002, Brinkman 2003, Brinkman et al. 2002). Although fence entanglements occur, they do not account for significant losses in white-tailed deer populations (Matschke et al. 1984). Nixon et al. (1991) documented mortality of two fawns with broken cervical vertebrae that had collided with fences, but did not distinguish the type of fence that caused the mortalities. While electric fencing has been shown to be effective in deterring movement of white-tailed deer (George et al. 1983), we were unable to find reports in the literature of a deer being entangled and dying in an electric fence.

Radiocollars (Advanced Telemetry System, Isanti, Minnesota) equipped with activity and mortality sensors were placed around the neck of each captured deer and individual deer were located by ground triangulation two to three times per week (Brinkman 2003, Brinkman et al. 2000, DePerno et al. 2003). When the mortality signal for #393 was detected, cause of death was determined from field necropsy and ancillary evidence at the site of the mortality (White et al. 1987).

On the morning of 16 May 2002, we received a mortality signal from #393 and located the animal entangled in a 1.2 m, four-strand smooth wire electric fence (K-Fence Inc., Zumbro Falls, Minnesota). The top three strands of the fence were charged electrically and the bottom strand was the uncharged ground; all strands were spaced equally. A low-impedance energizer provided 5,000-7,000 volts of power at a three-second pulse rate. The fence was supported by 10 cm x 10 cm x 1.2 m pressure treated wooden posts placed 5 m apart. Additionally, the fence was oriented across the middle of a steep slope (grade = 50 to 75%) along the edge of a pasture. Based on the angle of the carcass, we think the animal approached the fence from the down slope, attempted to jump uphill, became entangled, and fell forward. We think the steep grade combined with the animal jumping uphill resulted in the entanglement. The rear legs of the animal were caught between the top two strands of wire and the remainder of the animal was touching the ground and the uncharged wire.

Electric current passing through the body can cause irritation, burns, unconsciousness, or immediate death depending upon the strength (amperage) of the current, degree of "grounding" (earth contact), duration of the shock, and degree of moisture present at the point of contact. Additionally, paralysis to the areas of the brain that control breathing might lead to complete cessation of respiration; ventricular fibrillation is usually the cause of death (Cooper 1996). Deer #393 had extensive burns on both hind legs between the hoof and pelvis. As noted by Cooper (1996), the burns were most severe at the points of contact with the electric wires. Field necropsy of the animal revealed no additional injuries. Deer #393 was located alive on 14 May 2002,

two days prior to the mortality, was pregnant with two female fetuses, and appeared to be in excellent condition prior to the accident. The evidence strongly indicates the ultimate cause of death was electrocution.

We thank landowners Ed and Ellen Simon for allowing access to their property. We thank J. Tardiff, J. C. Shaw, and S. K. DePerno for comments and suggestions on an earlier draft of the manuscript. Publication costs were provided by North Carolina State University.--*Christopher S. DePerno[1], Benjamin J. Bigalke, Jonathan A. Jenks, Brian S. Haroldson, and Robert G. Osborn. Minnesota Department of Natural Resources, Farmland Wildlife Populations & Research Group, 35365 800th Avenue, Madelia, MN 56062 (CSD, BSH, RGO), Department of Wildlife and Fisheries Sciences, Box 2140B, South Dakota State University, Brookings, SD 57007-1696 (BJB, JAJ). [1]Current address: Fisheries and Wildlife Program, Turner House, Box 7646, North Carolina State University, Raleigh, NC 27695-7646. E-mail address: chris_deperno@ncsu.edu*

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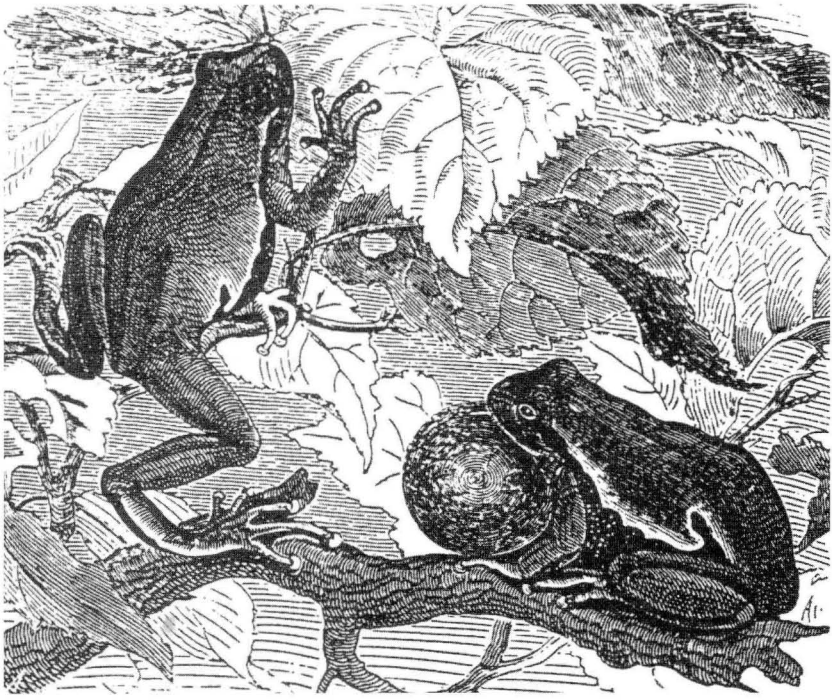
Received: 21 July 2004 *Accepted: 15 May 2005*

Associate Editor for Mammalogy: Brock R. McMillan



CONTINUED RANGE EXPANSION BY THE CAVE MYOTIS -- The cave myotis (*Myotis velifer*) is a cavernicolous bat that ranges northward from Honduras to the southern Great Plains and southwestern United States. Its known range in the United States includes the states of Kansas, Oklahoma, Texas, Arizona, New Mexico, and small, southern portions of Nevada and California (Fitch et al. 1981, Hayward 1970). The cave myotis inhabits caves, mines, and buildings, depending on time of year and specific roost requirements (Fitch et al. 1981, Hayward 1970, Kunz 1973, Sparks and Choate 2000). Before European settlement of areas within the range of the cave myotis, it likely was restricted to caves (Sparks and Choate 2000). However, it has adapted successfully to conditions that exist in roosts other than caves (Sparks and Choate 2000). The most obvious evidence of these adaptations is the formation of colonies during the summer months, when maternity or bachelor colonies are established in buildings, such as barns, and mines (Fitch et al. 1981, Kunz 1973, Sparks and Choate 2000).

In Kansas, the cave myotis is most abundant in the Red Hills of the south-central portion of the state in Barber, Clark, and Comanche counties. Most summer and transient roosts and hibernacula are located in the gypsum caves found in this region (Hayward 1970, Kunz 1973, Sparks and Choate 2000). However, the range in Kansas also includes areas adjacent to the Red Hills where there are no caves (Sparks and Choate 2000). Roost sites in these adjacent areas typically are buildings that are used by reproductive female cave myotis as maternity roosts, although bachelor and transient roosts have been observed (Kunz 1971).

In 1968 and 1971, specimens of cave myotis were collected from Pawnee and Edwards counties, respectively. As of 1971, when the most recent and comprehensive study on the cave myotis in Kansas was published, records (KU 119286-94) from Larned, Pawnee County were the northernmost for this species (Kunz 1971). Specimens collected from the locality in Pawnee County consisted of eight males and one female. Based on the sexual composition of individuals from Larned, Kunz (1971) suggested that males might use more peripheral areas than females.

In 2002, a colony of cave myotis was discovered in a building located on private property 4 mi. S., 1/2 mi. E. Nekoma, Rush County, about 32 km north of the locality in Pawnee County. According to the landowners, bats inhabited the building for two or three years prior to 2002. In May of 2002, a lactating female (MHP 36648) was obtained from the colony and subsequent examinations of the colony revealed that the roost was serving as a maternity site. The implications of this discovery contradict the suggestion of Kunz (1971) in that males apparently are not alone in traveling great distances to find optimal roost sites. It might be that males first locate peripheral roosts before females move in. The Rush County record not only offers new insight into summer movements of the cave myotis in Kansas, but also extends the northern range of the cave myotis and represents the

northernmost locality in Kansas and the United States. Finally, this maternity colony provides evidence that the range of the cave myotis continues to expand.

We thank the landowners (Scott and Diane Seltman), who have allowed access to their property, and Fort Hays State University for funding -- *Shauna R. Marquardt[1], Jerry R. Choate, and Stanley D. Roth, Jr. Sternberg Museum of Natural History and Department of Biological Sciences, Fort Hays State University, Hays, KS 67601 (SRM, JRC), Kansas Biological Survey, University of Kansas, Lawrence, KS 66047 (SDR). [1]E-mail address: red_batt@yahoo.com*

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Received: 1 November 2004 *Accepted: 9 May 2005*

Associate Editor for Mammalogy: Brock R. McMillan

Book Reviews

THE QUINTESSENTIAL COMPANION FOR NORTH AMERICAN BIRDERS

The Birdwatcher's Companion to North American Birdlife. Christopher W. Leahy. 2004. Princeton University Press, Princeton, NJ. 1039 pages. $39.50 (cloth).

How do birds drink? How fast can a hummingbird fly? Why do some birds balance on one leg? How fast can an ostrich run? Why do some birds hop and others walk? What is the most abundant bird in the world? As an avian ecologist, these are just a smidgen of the many questions I have been asked by the public during the past several years. To answer these and similar questions, I typically do not reach for a text on ornithology or avian ecology. Rather, I have come to rely on a number of quick-reference, encyclopedic resources on birds, including John Terre's *The Audubon Society Encyclopedia of North American Birds*, Paul Ehrlich et al.'s *The Birder's Handbook*, David Bird's *Birder's Almanac*, Frank Todd's *10,001 Titillating Tidbits of Avian Trivia*, and Christopher Leahy's *The Birdwatcher's Companion: an Encyclopedic Handbook of North American Birdlife*. Each of these resources has its merits and shortcomings, but the latter tome has always held a special place in my heart and on my shelf because it was one of the first bird books that I had purchased as a budding birder and ecologist.

The Birdwatcher's Companion was revised in 2004 under a new title, *The Birdwatcher's Companion to North American Birdlife*, and by a new publisher, Princeton University Press. This substantial work builds on Leahy's previous edition published in 1982. Hailed by the publisher as the quintessential, alphabetically arranged guide to North American birdlife, the new edition of *The Birdwatcher's Companion* is over 100 pages longer than the first edition, but, overall, the style and format have not changed much between the two editions. The *Companion* begins with a brief chapter in which the author describes how to use the book, how it is organized, and what features or topics are and are not included. Although the title suggests that the book covers birds from all of North America, it focuses on the continental United States and Canada. For some broad or unique topics, however, Leahy borrows examples from other regions (e.g., ostrich running speed, megapode incubation).

The heart of the *Companion* is its authoritative definitions and essays on topics related to birds and bird study. The author has revised and updated some entries, added new ones, and deleted or combined others. For example, our understanding of the evolution of birds, feathers, and flight, although still incomplete, has advanced substantially since the first edition, and Leahy makes an

admirable effort to update this entry with some recent discoveries (see EVOLUTION OF BIRDLIFE). Another entry explains the politically correct reasons behind the recent name change from OLDSQUAW to long-tailed duck. Some new entries, such as BIRD CHAT GROUPS, LISTSERVS, and RARE BIRD ALERTS, reflect recent changes in our modes of communication. The sections on ALEUTIAN ISLANDS, PRIBOLOF ISLANDS, and GAMBELL in the first edition are incorporated into a new section called ALASKA in the current edition. The text of most sections, however, has not changed from the original edition.

The book ends with a subject-specific bibliography and six appendices, including 1) an up-to-date checklist of North American birds, 2) a checklist of casual and accidental species, 3) Sibley and Monroe's alternative phylogeny of North American bird families, 4) a classification of major categories of extinct birds, 5) a list of exotic species, and 6) a birdwatcher's calendar (which addresses temporal aspects of bird finding). Over 25 illustrations (pen-and-ink line drawings) by Gordon Morrison were updated and refreshed; many of the line drawings are vast improvements over the originals. Gone are the color plates that graced the original edition; some have been converted to black-and-white line drawings and others have been eliminated altogether.

As with the first edition, I was impressed with the breadth and content of the new edition. At times, I found myself randomly thumbing through the entries, learning about the meanings of esoteric words or the origins of colloquial names. I found few things in the recent edition to quibble about. There were a few typographic errors (e.g., on page 678, BIRD CHAT was listed as BIRDCHAT), but overall these were inconsequential. In some entries, I was disappointed that the information in the recent edition remained essentially unchanged from the original edition. For example, despite many recent publications on grit in birds (e.g., its digestive functions, its retention time), Leahy incorrectly states that grit "accumulates in the stomach throughout the bird's life." The individual entries of well-known birding-finding localities seemed biased toward the coastal regions or the author's experiences. Where, for example, are the entries for the Cheyenne Bottoms and Quivira National Wildlife Refuge in Kansas, two of the most important stopover areas for migratory shorebirds in the western hemisphere? As in other encyclopedic works, the author uses cross-referencing to create a balance between excessive consolidation and unnecessary repetition. Some entries, however, could have used more cross-referencing. For example, PTILOPODY (i.e., feathered toes and legs) is defined and then cross-referenced to LEG/FOOT, but ptilopody is not mentioned by name in the text of the latter section even though feathered toes and legs were mentioned twice. Some words are not cross-referenced and thus may be found only by chance or by extensive searching. For example, below are two questions that were posed to me by colleagues. What is the term that is used to describe scientific names in which the generic and specific epithets are identical, as in *Xanthocephalus xanthocephalus* (yellow-headed blackbird) and *Perdix perdix*

(gray partridge)? What term is used to describe a bird that has characteristics of both a male and a female? The answers to these questions are in this book, but there is no easy way to find them. (For the trivia or crossword buffs, TAUTONYM is a Latin binomial in which the generic and specific names are the same, and GYNANDROMORPHISM is a rare genetic abnormality in which characters of both individuals are combined in a single individual.)

Despite these shortcomings, as with the previous edition, I enjoyed perusing the contents of this book and randomly reading essays and definitions. The *Companion* is not a compendium of everything known about North American birds, but it is an impressive and authoritative compilation of information on one of the most-studied groups of organisms in North America. Birders and bird enthusiasts will enjoy browsing through this book for its myriad of facts and entertaining essays. Leahy's light-hearted writing style, humorous anecdotes, and personal experiences add zest to many topics. Weighing just over 3.5 pounds, this beefy reference book is well worth the cost for any birder and will become a valuable resource for any biologist, ecologist, or manager who responds to questions from the ever-inquisitive public. In short, this book will appeal to those who love birds.—*Lawrence D. Igl, Northern Prairie Wildlife Research Center, U.S. Geological Survey, 8711 37th Street SE, Jamestown, ND 58401.*

THE SOONER STATE BIRD ATLAS

Oklahoma Breeding Bird Atlas. Dan L. Reinking, editor. 2004. University of Oklahoma Press, Norman, Oklahoma. 519 pages. $34.95 (paper).

In Oklahoma, forest meets prairie, prairie meets mesa, and throughout, our native ecosystems are shaped by human land use. Across this shifting mosaic of habitats, animals find food, raise young, and disperse to find other members of their species. Management for these species is best informed when it springs from a common baseline of knowledge about distributions across the entire management area. For birds, that baseline can be effectively established with a breeding bird atlas.

Based on methods developed by the British Trust for Ornithology (J. T. R. Sharrock. 1976. The Atlas of Breeding Birds in Great Britain and Ireland. T. and A. D. Poyser, Staffordshire, U.K.), a breeding bird atlas is a geographically referenced survey for all breeding species in an area. The objectives are to map distributions and to ascribe some degree of confidence that the species detected belong to a breeding population. Breeding bird atlases present a snapshot of distributions compiled from data collected over several years, and are ultimately intended to serve as long-term monitoring tools. For example, *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991* (D. W. Gibbons, J. B. Reid, and R. A. Chapman. 1993. T. and A. D. Poyser, Staffordshire, U.K.) documents changes in distribution since the first atlas effort in the 1960's. In North America, several second atlas projects are underway or have been completed.

In 2003, while working with a team to design the sampling plan for Pennsylvania's second atlas, I moved to Oklahoma and was delighted to learn that an atlas had recently been completed and "the book" was pending. With a mix of professional scrutiny and a transplanted birder's anticipation, I cracked open my copy of the *Oklahoma Breeding Bird Atlas.*

The book exceeded my expectations on both counts. First, the amazing cover photograph of a scissor-tailed flycatcher welcomes and whets the appetite for more. Once inside, 220 field guide-quality photographs reward the reader for turning each page. To take nothing away from the superb artwork common to atlas texts, the photography presented with the species accounts for this atlas raises the bar considerably.

The text begins with acknowledgments and details of the field methods and analysis, basic results, and descriptions of Oklahoma habitats. This information is presented clearly and concisely. I encountered one minor typographic error (a missed period) in this section. I am a little disappointed that the section on Vegetation of Oklahoma (pages 13-17) does not express more emphatically the widespread conversion of grassland to woodland due to proliferation of invasive eastern red cedar (*Juniperus virginiana*). This idea is briefly mentioned on page

14, as is fire suppression as a problem under the headings for specific vegetation types, but I see red cedar invasion as an overarching influence on the distribution of breeding birds in multiple habitats across most of the state, and its passing mention in this text is a missed opportunity to get an important conservation message out to a large and diverse audience.

Like any atlas text, the species accounts (pages 20-463) are the where the rubber meets the road. Here the 34 authors have done a superb job of presenting the relevant information in a disciplined, accessible package. Each account covers identification, breeding habitat, nesting ecology, rangewide and Oklahoma distributions, historical distribution, population trend, and references. Maps are presented with adjacent tables listing the total number of blocks in which the species occurred, broken into subtotals for confirmed, probable, and possible breeding evidence. Bold colored squares are used for the breeding codes, with solid circles representing nest locations. People with impaired ability to discriminate colors may have difficulty interpreting the breeding code maps, but the accompanying tables should help to clear up any confusion.

I could find only one typographic error in the species accounts ("scare" should be "scarce" on page 358). With respect to the data presented in the text, I would like to have seen the abundance code data presented for at least some species, but I appreciate the editor's comment on page 6 that these codes may have been applied inconsistently among observers and are of questionable value.

Relative to other atlases, the *Oklahoma Breeding Bird Atlas* was restricted to a stratified random sample of atlas blocks covering just one-twelfth of the state's land area, rather than coverage in every block. Given that the number of field workers (about 100) was at least an order of magnitude lower than that contributing to atlas efforts in some eastern states, it is a remarkable testament to the dedication of Oklahoma's birding community that even the sample of blocks was completed on schedule. For most breeding species, the 583 atlas blocks delineate the species' distribution accurately; supplemental records are included for nesting records of rare species that were not detected in atlas blocks.

In sum, the *Oklahoma Breeding Bird Atlas* presents timely information on a fascinating statewide avifauna in a clear and attractive package. The text is well-written and informative, and the photographs alone could reserve it a spot on even the most discriminating coffee tables. My copy, however, will remain at arm's reach for the foreseeable future, and I recommend a similar spot for it among the reading material of anyone interested in the natural history of the southern plains.—*Timothy J. O'Connell, Department of Zoology, Oklahoma State University, Stillwater, OK.*

SUGGESTIONS FOR CONTRIBUTORS

The Prairie Naturalist is devoted to research on the North American Great Plains and its biota. Manuscripts containing original material will be accepted from individuals without regard to membership in the Great Plains Natural Science Society.

Correspondence. Manuscripts and correspondence should be sent to Elmer Finck, Editor, *The Prairie Naturalist*, Department of Biological Sciences, Fort Hays State University, 600 Park Street, Hays, KS 67601-4099. Telephone: (785) 628-4214. FAX: (785) 628-4153. E-mail: efinck@fhsu.edu. Allow about six months for manuscript review. Book reviews and books for review should be sent to Douglas H. Johnson, Book Review Editor, Department of Fisheries, Wildlife, and Conservation Biology, 204 Hodson Hall, University of Minnesota, St. Paul, MN 55108. Telephone: (612) 624-4716.

Style. Authors should follow a clear and concise style. Use active voice whenever possible. The CBE Style Manual (5th edition or later) is a good reference for manuscript preparation and general rules of style; note, however, that we prefer the style of Literature Cited given at http://www.fhsu.edu/biology/pn/prairienat.htm. Style rules may also be obtained by writing the Editor.

Preparation. Manuscripts should be printed on one side of 8½ x 11 inch paper, with pages numbered, double spaced throughout, and have a one-inch margin all around. Do not include any headers or footers. Lines should not be numbered. Longer papers may have sections, with appropriate headings capitalized and centered. Four copies are required for review purposes. Manuscripts of more than two pages and containing figures and/or tables will be printed as Articles. Manuscripts of two or fewer pages and lacking tables and figures will be printed as Notes. All Articles must have an abstract and an alphabetized key word list. Submission of the final manuscript must be accompanied by a copy of the text on a PC-formatted 3.5 inch diskette in Word or WordPerfect format.

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References cited in the text of Articles and Notes should be listed at the end of the manuscript under the Literature Cited heading. Journal titles should not be abbreviated. In a listing for a book, the title is not underlined, and the number of pages is not included. See a recent issue of *The Prairie Naturalist* or the Style Rules for specific examples.

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The Prairie Naturalist (ISBN 0091-0376) is published quarterly by the Great Plains Natural Science Society.

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1. Manuscripts on any aspect of the biology of the North American Great Plains and the organisms living in this region will be considered for publication. Studies on grassland habitats in areas outside this region will also be considered.
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20. The Editor will prepare an annual report for presentation at the annual meeting of the Great Plains Natural Science Society. The report will include the number of pages published, separated by type of article, and the extent to which page charges were assessed.
21. Suggestions for contributors will be published annually in the March issue.

THE COVER AND ITS ARTIST

The horned lark (*Eremophila alpestris*, upper bird) and snow bunting (*Plectrophenax nivalis*, lower bird) share an affinity for open, nearly bare ground. In winter, these two hardy species sometimes flock together.

The horned lark breeds on open ground across much of the United States and Canada. The female scrapes a shallow cup in the soil then weaves a nest of grass and small roots. Only the female incubates, but both parents feed the nestlings. In most of its range, the horned lark is a year-round resident; only far northern populations migrate for the winter. It forms large flocks in winter, sometimes up to several hundred birds foraging for seeds together.

The snow bunting breeds in the high arctic and overwinters in the Great Plains and eastern North America. Males return to the frozen breeding grounds in early April. The snow bunting is one of the few arctic species that nests in rock crevices instead of open ground. Males feed their mates during incubation, then both parents feed the nestlings. The snow bunting congregates in winter, sometimes forming flocks hundreds strong. Even in the bitterest cold, the snow bunting roosts individually, nestled into the snow instead of clustering together.

Beth Peluso has drawn animals since she could hold a pencil. She uses watercolor and pen and ink to portray birds (her favorite subject), insects, plants, wildlife, and western landscapes. Her artwork has appeared in *The Prairie Naturalist*, an Arizona Fish and Game report, several online publications, and other scientific journals. She currently is writing and illustrating a children's book on Rocky Mountain fire ecology.

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Manuscript submissions and correspondence should be directed to Elmer J. Finck, Editor, *The Prairie Naturalist*, Department of Biological Sciences, Fort Hays State University, 600 Park Street, Hays, KS 67601-4099. More detailed instructions for authors can be found on *The Prairie Naturalist* web site at: http://www.fhsu.edu/biology/pn/prairienat.htm.

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